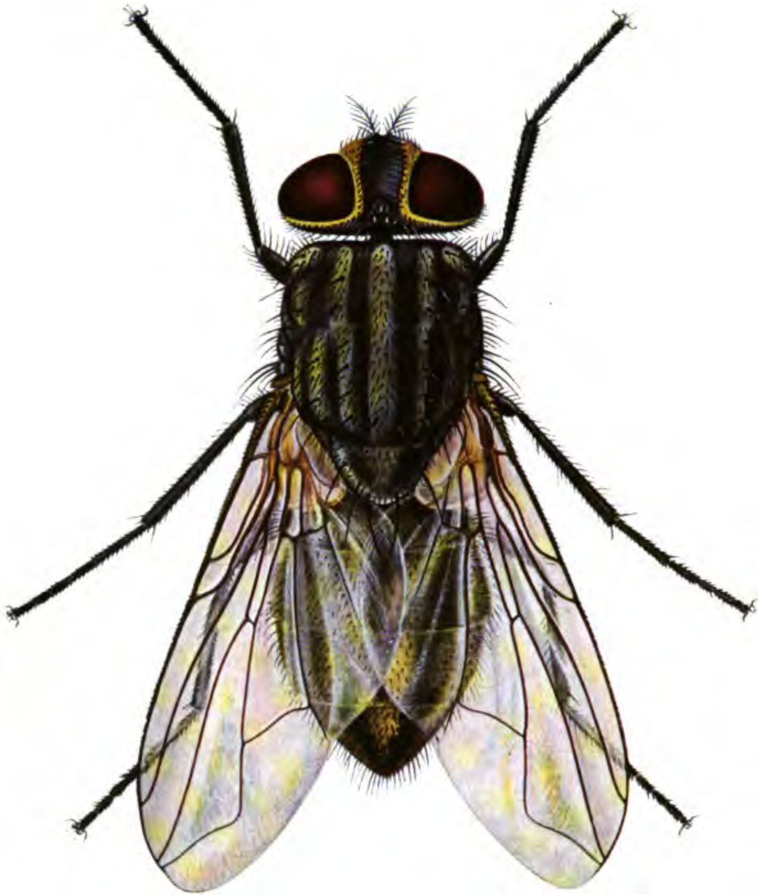
W. B. Stevens

THE HOUSE FLY—DISEASE CARRIER



THE HOUSE FLY—DISEASE CARRIER

THE

HOUSE FLY

DISEASE CARRIER

AN ACCOUNT OF ITS DANGEROUS ACTIVITIES AND OF THE MEANS OF DESTROYING IT

BY

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INTRODUCTION

IT is only within the last twelve years that the dangerous character of the common house fly has been known; and only within the last two years have the people at large begun to wake up to this danger and to inquire concerning the means by which this fly can be kept down. The writer published some account of its life history in a bulletin on household insects published by the U. S. Department of Agriculture in 1896. Later he made some experiments with regard to remedies, and in 1900 published a rather lengthy paper on the insect fauna of human excrement with especial reference to the carriage of typhoid fever by flies. Within the last two years, however, articles relating to the so-called house fly in connection with its disease-carrying possibilities have been published literally by the thousand, and this interest, perhaps having its origin in the United States, has spread to nearly all parts of the civilized world, and yet in no one of these published articles is the whole story told. No one can find in condensed and convenient shape the general information he desires in regard to this insect. The publishers of this book, realizing this fact, have invited the author to attempt to fill this want.

This book is not intended to be a scientific monograph; it is simply an attempt to tell in an understandable way what is known about the subjects indicated in the title.

And mention of the title brings up the point as to whether the writer was justified when he proposed the name typhoid fly for the old and well-known house fly at the meeting of the Committee of One Hundred on Public Health at the meeting of the American Association for the Advancement of Science, in Baltimore, during the Christmas week in 1908. He has been criticized for making this suggestion by the Association of Economic Entomologists' Committee on Popular Names and also by certain medical men. The objections have been that this name would indicate the belief on the part of the proposer and of those who should subsequently use it that the house fly is the sole carrier of typhoid or that it is the principal carrier of typhoid; in other words, that it is given too much prominence from the standpoint of the etiology of typhoid fever. As a matter of fact, however, the writer never claimed that it was the only carrier of typhoid or that it was the principal carrier of typhoid except under certain peculiar conditions. In fact, the suggestion seems to him to have been quite sufficiently guarded. It was as follows: "The name 'typhoid fly' is here proposed as a substitute for the name 'house fly' now in general use. People have altogether too long considered the house fly as a harmless creature, or at the most simply a nuisance. While scientific researches have shown that it is a most dangerous creature from the standpoint of disease, and while popular opinion is rapidly being educated to the same point, the retention of the name 'house fly' is considered inadvis-

able as perpetuating in some degree the old ideas. Strictly speaking, the term 'typhoid fly' is open to some objection as conveying the erroneous idea that this fly is solely responsible for the spread of typhoid, but, considering that the creature is dangerous from every point of view and that it is an important element in the spread of typhoid, it seems advisable to give it a name which is almost wholly justified and which conveys in itself the idea of serious disease. Another repulsive name that might be given to it is 'manure fly,' but recent researches have shown that it is not confined to manure as a breeding place, although perhaps the great majority of these flies are born in horse manure. For the end in view, 'typhoid fly' is considered the best name."

As a matter of fact this name has been adopted very generally. The newspapers took it up with avidity, and during the summers of 1909 and especially of 1910, many good journals conducted a constant editorial campaign, almost every issue during the summer months containing some reading matter calling attention to the danger of the creature and the necessity of fighting it. It is undoubtedly true that people will fear and fight an insect bearing the name "typhoid fly" when they will ignore one called the "house fly," which they have always considered a harmless insect. So to gain the practical end the retention of the name "typhoid fly" seems by all means to be advisable. The only substitute suggested in the two years since this term has been adopted which ap-

proaches it for suggestiveness and availability is the name "filth fly," proposed by Dr. C. W. Stiles, of the U. S. Public Health and Marine-Hospital Service. But "filth fly," while a nauseating name associated as it must be with the dinner tables of unscreened houses, carries simply the noisome idea and not the dangerous idea, and the latter is one that will induce people to fight.

It will not be an easy fight. The species is firmly intrenched; it multiplies with startling rapidity, and its breeding places are everywhere. Improved sanitary methods in cities and the gradual disappearance in cities of horse stables, due to the rapid increase in the number of motor vehicles, are bringing about a decided lessening of the myriads of flies in the cities. In small towns, however, and in the country and at army posts, and especially in concentration camps, and wherever large bodies of men are brought together for temporary purposes in construction work, there is great need of intimate practical knowledge of the typhoid fly and of the measures to be taken against it. The residents of cities must also have this knowledge, but they need it less than the others.

Acknowledgments of assistance from others will be made in the text from time to time. The writer wishes especially, however, to thank Prof. S. A. Forbes, Dr. C. W. Stiles, and Dr. B. H. Ransom for allowing him to use their very valuable but as yet unpublished notes on several aspects of the fly question. He wishes also to thank Mr. R. B. Watrous, Secretary of the

American Civic Association, for access to his large correspondence on the fly crusade. He is also indebted to Mr. Gilbert H. Grosvenor, editor of the National Geographic Magazine, and to Mr. Robert Newstead, for permission to use certain illustrations which will be found properly accredited in the text.

The House Fly—Disease Carrier

I

ZOOLOGICAL POSITION, LIFE HISTORY, AND HABITS

Zoological Position

ZOOLOGICALLY speaking, this insect belongs to the order Diptera, or two-winged flies. In this order it is the type of a superfamily known as the Muscoidea, of a family known as the Muscidæ and of the genus Musca, the specific name given to it originally by Linnæus being *domestica;* and among zoologists it is referred to as *Musca domestica* L.

The superfamily Muscoidea, to which it belongs and of which it is the type, is a very large group containing a number of families and many species which so closely resemble the house fly that to the untrained eye they cannot be distinguished. Dr. David Sharp, in the Cambridge Natural History, writing of the house fly, states that "it sometimes occurs in large numbers away from the dwellings of man," and the writer is often asked to explain why parties camping in the Northwest, on the prairies for example, many miles away from human habitations, almost immediately find their camps infested with the house fly. The answer to such questions, and possibly the answer to the

statement made by Doctor Sharp, is that the flies found under such conditions are not house flies, but some species closely resembling *Musca domestica.* In the family Tachinidæ, a group composed almost entirely of species which lay their eggs upon other living insects, there are many species which almost precisely resemble the gray-and-black-striped house fly. In the family Dexidæ, of similar habits, there are also many which closely resemble the house fly. In the family Sarcophagidæ, which includes most of the so-called flesh flies, the species of which either live in carrion or excreta or in dead insects or in putrid matter, and are occasionally parasitic, as with the species which breed in the egg-masses of grasshoppers, there are also many species hardly to be distinguished from Musca. There is another great family, the Anthomyidæ, which has many species which closely resemble the house fly and give rise to many mistakes in identity. These insects in their early stages feed upon decaying vegetable matter and also to some extent upon growing plants, and a few prey upon the eggs of grasshoppers. Then, too, in the family Muscidæ itself there are many genera of similar habits and similar appearance. The writer once, as a test, selected twenty distinct species from among these insects and carefully pinned them into a tray, asking chance visitors for several weeks to pick out the true house flies from among them. No one was ever able to distinguish between the different forms by looking at them with the naked eye.

The habits of the different genera of Muscidæ are

rather uniform, except that with a few of them the adults bite and suck blood, while the majority, like *Musca domestica,* do not. The tsetse flies of Africa, belonging to the genus Glossina, bite, as also do the stable flies of the genus Stomoxys and the cattle flies of the genus Hæmatobia (this genus includes the so-called horn fly of cattle). Of the other genera, Graphomyia, Morellia, Mesembrina, Pyrellia, Pseudopyrellia, and Phormia all breed in excrementitious matter. The genus Myospila, formerly placed in the Muscidæ but really anthomyid, is also a breeder in this material. The flies of the genus Muscina breed in decaying vegetation and in cow dung, as also do those of the genus Pollenia. Those of the genus Cynomyia and of the genus Calliphora and of the genus Lucilia breed in dead animal matter, while *Chrysomyia macellaria*—the famous screw-worm fly—breeds in living flesh.

Some of these flies are occasionally found in houses, and further consideration of them will be found in Chapter V. For practical purposes they are all equally dangerous, as possible disease carriers, and to the practical person there is no especial need to distinguish among them; but fortunately the house fly is the only one that comes in abundance to houses. It is the only one which really deserves the term domestic.

For the two following paragraphs, which indicate the easiest method of distinguishing the house fly from any of its allies, I am indebted to Mr. D. W. Coquillett, an authority on the order Diptera:

"From nearly all the other kinds of flies that resem-

ble it, the house fly can be distinguished by having no bristles on the sides of the thorax above the attachment of the last pair of legs and by having the vein that ends near the tip of the wing distinctly elbowed, a short distance before its apex. Several different kinds of Tachinidæ, Dexidæ and Sarcophagidæ have a superficial resemblance to the house fly, and, like it, have the elbowed vein, but all of them differ from the house fly in possessing a row of bristles above the point of attachment of the last pair of legs. The only other family containing species that might be mistaken for the house fly is the Anthomyidæ, but none of these has an elbowed vein.

"In the foregoing paragraph I stated that the house fly can be distinguished from *nearly* all of the other kinds of flies that resemble it by the two characters mentioned. We have, in this country, a species agreeing with it even in regard to the two characters given. Indeed the resemblance is so close that only an examination under a lens or microscope will reveal the principal difference existing between these two species. I refer to *Musca autumnalis* DeGeer.* In the male of this form the eyes are in contact on the upper part of the head, whereas in the male of the house fly the eyes are widely separated and the black stripe between them is of nearly the same width throughout its length. In the female of *autumnalis* the dark stripe between the eyes is only as wide as the added breadth of the narrowest part of the two gray stripes which

*The *Musca corvina* Fabricius, 1781.

border it, while in the female of the house fly this dark stripe almost touches the eyes. *Autumnalis,* like its near relative, is almost cosmopolitan, but appears to have been rarely met with in this country."

Possibly a simpler way of putting it would be as follows:

Musca domestica has four black lines on the back of its thorax. All Sarcophagidæ have three such black lines. Most Tachinidæ have four such black lines, but the Tachinidæ have the bristle of the antennæ smooth, whereas in *Musca domestica* this bristle is feathered. From all Anthomyidæ, *Musca domestica* is at once separated by the bent vein near the tip of the wing. Moreover, *Musca domestica* has no bristles on the abdomen except at the tip which separates it from all others except some Tachinids and many Anthomyids, but from these it is separated by the characters given above.

Musca domestica is not alone in its genus. There are fifteen species of the genus Musca according to Bezzi and Stein in their Catalogue of the Palearctic Diptera. In North America there are thirteen species of Musca, according to Aldrich. Of none of these other species of Musca do the habits appear to be known. There is, however, an Indian species, *Musca entæniata,* which breeds in the same fecal masses with the typhoid fly.

Life History

A long experience with the study of insects has indicated the somewhat remarkable fact that it is about the commonest things in general that we know the least. When Mr. C. L. Marlatt and the writer began in 1895 to work on the subject of household insects, we discovered that very few of the species found so abundantly in households were included in the museum collections. There would be a large series of a rare beetle from Brazil, but no specimens of the common house cockroach, for example; and when we began to look into the literature of their life histories we learned that published accounts of their transformations were even more scarce than the specimens in the collections. Doctor Hewitt (1910) calls attention to the vision of Sir James Crichton Browne of the aged person showing the wondering child the only existing specimen of the house fly, in the British Museum. This was intended as a prophecy, but it would not be surprising if before the recent house fly crusade began there really was only one specimen of the house fly in the British Museum.

With this condition of affairs existing in general, it is perhaps not so surprising that an exhaustive study of the conditions which produce house flies in numbers has really never been made. The life history of the insect was, down to 1873, mentioned in only a few old European works and one more modern one (Taschen-

berg).* In 1873, Dr. A. S. Packard (1874), then of Salem, Mass., studied the transformations of the insect and gave descriptions of all the stages, showing that the growth of a generation from the egg to the adult state occupies from ten to fourteen days. In 1895, the writer traced the fly's life history, discovering that 120 eggs are laid by a single female at a time and that in Washington in midsummer a generation is produced in ten days.

Substances in Which This Fly Passes Its Early Life

It is safe to say that the typhoid fly will breed in almost any fermenting organic matter, and it is also probably safe to say that if given its preference it will lay its eggs on a pile of horse manure. The writer once estimated that under ordinary city and town conditions more than ninety per cent. of the flies present in houses have come from horse stables or their vicinity, and he is still inclined to think that this estimate is probably correct. But the eggs will also be laid upon the excreta of almost any animal. Cow manure drying rapidly in a dry season and forming a hardened caked surface is not a favorable nidus, yet this fly is reared from cow manure at times. Many other species of flies prefer cow manure, and a long list of

*The best of these old papers is little known. It was published at Nurenberg in 1764, and is entitled "Geschichte der gemeinen Stubenfliege, Herausgeben von J. C. Keller" and covers thirty-four pages of text and four plates. The real author is said by Hagen to be Freiherr Friedrich Wilhelm von Gleichen (genannt Russworm).

species reared from this substance has been published by the writer (1901).

The typhoid fly is, possibly next to horse manure, attracted to human excreta, and not only visits it wherever possible for food, but lays its eggs upon it and lives during its larval life within it. It will not only do this in the latrines of army camps, in the open box privies of rural districts and small villages, but also upon chance droppings in the field or in the back alleyways of cities, as has been repeatedly shown experimentally in Washington.

It may very readily happen that the flies of any given neighborhood have come from a single source, and that the substances in which they breed differ according to locality and according to the supply of breeding substance. Under ordinary city conditions, undoubtedly the most frequent nidus is in the horse manure of stables, but when the conditions in a community of a radically different nature are studied the result is sometimes surprising. In the course of his investigations of conditions in small towns with especial reference to the hookworm disease, Stiles has found that in cotton-mill towns, for example, the privies may be a much more important breeding place of flies than the manure piles, not only more important since flies breeding in this substance are more likely to carry disease germs, but also numerically more important; for you may have 250 uncared-for privies and perhaps only one or even no manure pile. And there are communities also where horses are scarce and pigs are

numerous. Stiles has seen great accumulations of pig manure fairly swarming with fly larvæ.

With regard to ordinary kitchen refuse, such as is found in the garbage pail, it is the opinion of Prof. J. S. Hine, of the Ohio State University, who has paid much attention to the subject, that, while house flies visit garbage in numbers, they appear in most cases to be after food only, as only a few specimens of this species were reared from such material during the season when he was at work.

With fermenting vegetable refuse from the kitchen, he found that the very common fly which bred in it was not the typhoid fly, but *Muscina stabulans,* the so-called stable fly. Hundreds of these flies were reared and their larvæ were exceedingly abundant in all of the samples of garbage examined. *Musca domestica* was also reared, as was also another species known as *Phormia regina,* but it seems from these observations, although they were limited to a single locality in Central Ohio, that the recently acquired general opinion to the effect that the typhoid fly breeds abundantly in vegetable refuse when it has reached the proper fermenting stage is due many times to the mistake of considering the stable fly and its larvæ as those of *M. domestica.* And this is an important point, since the stable fly is rather rarely found in houses and on food and therefore is not an important carrier of disease.

The substances in which flies will breed were carefully investigated in the city of Liverpool by Mr. Robert Newstead, lecturer in economic entomology and

parasitology in the School of Tropical Medicine of the University of Liverpool in 1907. Mr. Newstead is of the opinion that the chief breeding places of the house fly in Liverpool should be classified under the following heads: (1) Middensteads (places where dung is stored) containing horse manure only; (2) Middensteads containing spent hops; (3) Ash pits containing fermenting materials. He found, as has been the experience of observers in this country and India, that the dung heaps of stables containing horse manure only were the chief breeding places. Where horse and cow manures were mixed the flies bred less numerously, and in barnyards where fowls were kept and allowed freedom comparatively few flies were found. Only one midden containing warm spent hops was inspected, and this was found to be as badly infested as any of the stable middens. A great deal of time was given to the inspection of ash pits, and it was found that wherever fermentation had taken place and artificial heat had been thus produced such places were infested with house fly larvæ and pupæ, often to the same extent as in stable manure. Such ash pits as these almost invariably contained large quantities of old bedding or straw and paper, paper mixed with human excrement, or old rags, manure from rabbit hutches, etc., or a mixture of all of these. About twenty-five per cent. of the ash pits examined were thus infested, and house flies were found breeding in smaller numbers in ash pits in which no heat had been engendered by fermentation. The typhoid fly was also

found breeding by Mr. Newstead in certain temporary breeding places, such as collections of fermenting vegetable refuse, accumulations of manure at the wharves and in bedding in poultry pens. Mr. F. V. Theobald states that swarms of flies are reported to breed in the huge masses of dust-bin refuse in certain London suburbs. It does not appear to be certain, however, that these are *Musca domestica.*

In India, according to the observations of Surgeon Major F. Smith, of the Royal Army Medical Corps, horse manure is the most abundant breeding place for the house fly around military stations. He also reared this fly from cow dung in company with *Musca entæniata.*

DeGeer states that the larvæ of this species live in dung, but only in that which is warm and moist, or, stated better, which is in a condition of perfect fermentation. The importance of the factor of fermentation has already been referred to in the account of Mr. Newstead's observations and is insisted upon by Dr. C. Gordon Hewitt in Part II of his important paper on the Structure, Development and Bionomics of the House Fly. He points out that Keller, writing of this fly in 1790, reared the larvæ of the typhoid fly in decaying grain, where no doubt fermentation was taking place; also in small portions of meat, slices of melon, and in old broth. Doctor Hewitt also found that horse manure is preferred to all other substances by the female flies for egg-laying. He also found that the larvæ will feed upon paper and textile fabrics, such as woolen and cotton garments and sacking which were

foul with excremental products, if they were kept moist and at a suitable temperature. He also reared adult flies from decaying vegetables thrown away as kitchen refuse, and on such fruits as bananas, apricots, cherries, plums, and peaches, which were mixed when in a rotting condition with earth to make a more solid mass. He succeeded in rearing them in bread soaked in milk and boiled egg and kept at a temperature of 25° C., but he was unable to rear them to maturity in cheese.

The preference which the typhoid fly has for horse manure as a breeding nidus has been clearly shown by a multitude of observations. One of the early experiences of the writer consisted in an effort to keep the stables of the U. S. Department of Agriculture at Washington in a strictly sanitary condition. The manure was swept up and placed each day in a screened closet. As a result there was a notable diminution of flies in all of the buildings for hundreds of yards around for several weeks; whereas up to the time when the experiment began they had been a nuisance throughout that portion of the city. One of the many letters received which bear upon this point may be quoted:

WASHINGTON, D. C., February 10, 1908.

"DR. L. O. HOWARD,
Department of Agriculture,
Washington, D. C.

"DEAR DR. HOWARD:

"For the greater part of the last two years I have occupied a room on the third floor of the Faculty Club on the Campus of the University of California at Berkeley, Calif. During most of the time the number of flies in

the Club House has been notably small, considering the fact that the Club maintains a dining-room and its windows and doors are not screened. A year ago last fall there was a sudden incursion of flies, so that they created much annoyance in all parts of the Club House; and they were specially abundant in my room. I protected my windows by screens, and then captured the flies on sticky fly paper, securing in that way more than 2,000. The nuisance in other rooms continued several weeks longer, and then gradually abated. There was no recurrence at the corresponding season last fall.

"Recalling some statements of yours with reference to the life history of the house fly, I noted that the epidemic was coincident with the grading of the University athletic field, about 200 yards from the Faculty Club, and that in that grading many horses were employed, probably as many as fifty. So far as I am aware there are no horses stabled on the University campus, and I do not recall having seen any horse stables at a less distance than two blocks, or, say, three times the distance of the athletic field. These various relations of time and space serve to connect the local fly epidemic in a fairly definite way with the temporary proximity of a large number of horses.

"Yours very truly,

"G. K. Gilbert."

In an article entitled "Experiments on Transmission of Bacteria by Flies with Especial Relation to an Epidemic of Bacillary Dysentery at the Worcester State Hospital," Dr. Samuel T. Orton (1910), after describing a series of very interesting experiments indicating the spread of a species of bacillus throughout the institution by the agency of flies, describes a search made to discover the breeding places of the unusual number of flies infesting the hospital. Searching first for horse

manure, he found that there were only two such accumulations on the hospital grounds. The one at the stable was in a large masonry pit drained below and covered so that while not fly-proof it was dark and dry. No larvæ or puparia were found in the pit. The manure was molding and heating rapidly. Two other piles where the manure was kept dry and in the dark showed the same condition of rapid heating and molding and no larvæ were found. At the farm barn the manure was dropped through four traps where a pile accumulated, and was then taken to the part of the barn where the cow manure is collected and the two were mixed together. Here a considerable number of larvæ and puparia were found, but not in sufficiently great numbers to account for the swarms around the buildings. They were more abundant in the part of the pile which consisted of pure horse manure and grew noticeably less until the cow manure was reached, when they were very few. Examination of the pig pen showed piles of pig manure mixed with the straw bedding exposed to air and rain. This was badly infested; one ounce of material taken from a point a few inches below the surface displayed 868 puparia. Another prolific source was found in piles of spent hops and barley malt—brewery waste which had been hauled in as a fertilizer. The hops showed a tendency to mold rapidly, and the flies did not breed in it as abundantly as in the looser barley malt. In parts of the malt where there was plenty of moisture the maggots were extremely numerous; one ounce contained 1,018 mag-

gots. There had been considerable rain and the piles were damp throughout. At one place there was a layer of six or eight inches of soggy barley over the ground, which was simply crawling with larvæ. After six days of continued dry weather, however, they had practically all disappeared.

An interesting experiment was made. One pound of material from each of the breeding places was taken to the laboratory and kept in screen-covered glass jars for ten days, with the following result:

Stable manure..........	0	adult	flies	issued
Farm barn, horse end....	77	"	"	"
Farm barn, mixed.......	19	"	"	"
Farm barn, cow end.....	1	"	fly	"
Piggery manure pile.....	361	"	flies	"
Spent hops.............	129	"	"	"
Barley malt............	539	"	"	"

These results as recorded are very interesting and are probably in the main correct, although Doctor Orton states that the identification of species was by no means thorough and the determination of the house fly was made simply by observation of its size and general appearance and the characters of the mouth parts. It is possible that the stable fly (*Muscina stabulans*) may have formed a portion at least of the flies bred from the spent hops and the barley malt.

There is a statement in Taschenberg's Praktische Insektenkunde to the effect that the female house fly lays its eggs not only upon spoiled and moist foodstuffs, decaying meat, meat broth, cut melons, dead animals, manure pits, manure heaps, but even in cus-

pidors and open snuff-boxes. The entomological world has accepted the statement, with, however, some doubt as to the snuff-boxes. Prof. S. A. Forbes, however, informs the writer that August 22, 1889, he received from an old friend, T. A. E. Holcomb, then a druggist at Kensington, Ill., a box of snuff containing dipterous larvæ. From these dipterous larvæ Professor Forbes bred the true house fly. His recollection of the matter is very clear, and he has now in his collection a very under-sized specimen labeled *Musca domestica* and bearing an old pencil label in his handwriting, "Snuff, August 26th."

He afterwards called upon Mr. Holcomb in his drug store and learned that among his constant customers were some old foreigners who came so frequently to have their snuff-boxes filled that for convenience in serving them he was accustomed to keep an open box of snuff upon one of his show-cases, and from this box the specimens came.

A very important series of observations was carried on under the direction of Professor Forbes in the summers of 1908-1909 by his assistants, Mr. A. A. Girault, at Urbana, and Mr. J. J. Davis, in Chicago, for the purpose of ascertaining exactly what other substances aside from horse manure will serve as breeding places for house flies. The results of these observations, not previously published, have been placed at the writer's disposal by Professor Forbes. They constitute a very valuable addition to our knowledge on this subject. It was a surprise to find that nearly a thousand flies had

been reared from cow dung. This dung was in a stable, and it is to be presumed that the conditions were such that the dung did not dry readily and that there was no preferred food in the immediate vicinity. Preconceived notions are also somewhat upset by the rearing of 267 flies from carrion found in the street. The list as a whole is of the greatest practical interest and is as follows:

Date	*Media*	*Number house flies bred*
Sept. 1-3	Rotten water-melon and muskmelon	14
Aug. 18 and Sept. 8-11	Rotten carrots and cucumbers	23
Sept. 7	Rotten cabbage stump	1
Sept. 7	Banana peelings	1
Aug. 30	Rotten potato peelings	12
Sept. 25	Cooked peas	1
Oct. 1	Ashes mixed with vegetable wastes.	1
Sept. 7-14	Rotten bread or cake	8
Aug. 22	Kitchen slops and offal	193
Sept. 10-26	Mixed sawdust and rotting vegetables	41
Aug. 30-Sept. 4	Old garbage, city dump	15
Aug. 14 and 18	Rotten meat, slaughter houses	40
Aug. 30-Sept. 11	Carrion in street	267
Sept. 7	Seepage from garbage pile	1
Aug. 17-20	Hogs' hair, slaughter house waste	9
Aug. 23-28	Sawdust sweepings, Stock Yards slaughter house	110
Aug. 23	Sawdust sweepings, meat market	4
Aug. 16-28	Animal refuse, Stock Yards	39
Aug. 14	Contents of paunches of slaughtered cattle	168
Sept. 2-11	Rotten chicken feathers	258
Aug. 16	Chicken manure, stock-car dump	3
Aug. 31-Sept. 7	Cow-dung, stable, Urbana	997
Sept. 7-10	Cow-dung, outdoor yard	22
Sept. 6	Cow-dung, pasture	1
Aug. 24-Sept. 16	Human excrement	196

The Egg

The eggs are minute and glistening white, and they are all long ovoid in shape. In length they vary from one-~~sixth~~ 20 of an inch to a little longer. They are laid in clusters of small size and irregular shape, either on their ends or on their sides. Seen under a high power of the microscope, the polished surface appears to be covered with minute hexagonal markings such as is seen in what the histologist calls pavement epithelium. Each female fly lays on the average 120 eggs, or perhaps more, at a time and may lay several times. Forbes's assistants in Illinois found that eggs from a single fly vary from 120 to 150 in each deposit and that as many as four deposits may be made, or say, 600 eggs by a single fly (*in lit.*). One hundred and twenty was the number observed by the writer to be the average number, but Doctor Hewitt has counted as many as 150.

The duration of the egg stage, as observed in Washington, was usually eight hours; that is to say, eight hours after it was laid the egg hatched. These observations were made in midsummer and have not been repeated at other times of the year. Mr. Newstead in Liverpool found that the eggs hatched in periods varying from eight hours to three or four days, the average time being about twelve hours. But he noted that when laid in fermenting materials the incubation period was reduced to a minimum of eight to twelve hours. In a temperature of from 75° F. to 80° F. they hatched in from eight to twelve hours; in a temperature of 60°

Fig. 1.—Eggs, approximately natural size; photographed on surface of manure pile. (From Newstead.)

Fig. 2.—Eggs, approximately natural size. (From Newstead.)

F., in twelve hours, but at 45° F. they did not hatch until the third day, and then only when placed in a warmer temperature for the purpose of studying them under the microscope.

Doctor Hewitt has carefully observed the hatching of the eggs, and this is a process which has now become familiar to many Americans through the excellent moving-picture exhibitions given under the auspices of the American Civic Association from films prepared in England at the expense of Mr. Daniel Hatch, Jr.,

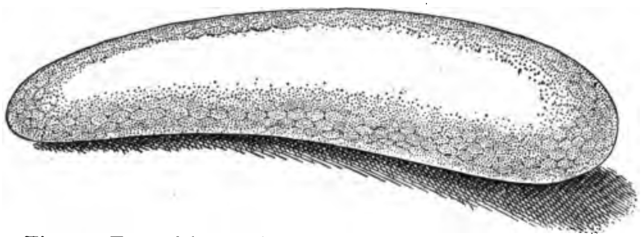

Fig. 5.—Egg of house fly; greatly enlarged. (Original.)

Chairman of the Fly-fighting Committee of the Association. Doctor Hewitt's description follows:

"A minute split appeared at the anterior end of the dorsal side to the outside of one of the ribs [referring to two distinct curved rib-like thickenings along the dorsal side of the egg]; this split was continued posteriorly and the larva crawled out, the walls of the chorion [the eggshell] collapsing after its emergence.

The Larva

We have just described how the egg hatches. The young larva as it issues from the egg is a slender

creature tapering from the blunt, round, hinder end to the pointed head end. It is glistening white in color and only about two mm. in length. It is extremely active and burrows at once into the substance upon which the egg from which it hatched had been laid, rapidly disappearing from sight. In the course of its growth it casts its skin twice, and therefore passes through three distinct stages of growth. In the first one the anal spiracles, or breathing holes, on the last segment, are contained in a heart-shaped aperture. After the first molt these spiracles issue in two slits, and after the second molt there are three winding slits.

In the third and last stage the larva is still white, sometimes appearing yellowish. It is slender and tapering in front, large and truncate behind. The head has a tiny papilla on each side. There is one great hook above the mouth orifice. On each side of the prothorax there are spiracles which show six or seven lobes. On the ventral base of the sixth and following segments there is a transverse fusiform, swollen area provided with minute teeth. The anal area is only slightly prominent, and shows two processes close together. The anal spiracles are prominent, less than their diameter apart, and each with three sinuous slits and a button at the base. In some cases two of the winding slits are apparently connected together. Within the head, or rather the anterior part of the body, is a chitinous framework consisting of several articulated parts called the cephalopharyngeal skeleton, which is indicated in figure 7.

Fig. 3.—Eggs, greatly enlarged. (From Newstead.)

Fig. 4.—Eggs, greatly enlarged—another view. (From Newstead.)

The rate of growth of the house fly larva varies according to temperature in much the same way as does the period of duration of the egg stage. In the writer's original observations in midsummer in Washington he found that the time from the hatching to the first molt was twenty-four hours; from the first molt to the second molt twenty-four hours; from the second molt to transformation to pupa seventy-two hours; making the duration of larval life five days. The larvæ are very active and migrate from place to place in a manure pile with facility. Mr. Newstead in Liverpool observed that they mature in the shortest period in fermenting materials in a temperature of between 90° and 98° F., but that they usually leave the hotter portions of the stable manure when it reaches a temperature of from 100° to 110° F. At 54° F. the larval stage was considerably prolonged, and larvæ kept at that temperature had not matured at the end of eight weeks.

Doctor Hewitt at Manchester, England, showed that larvæ of the first stage might molt as early as twenty hours after hatching, but that from twenty-four to thirty-six hours usually elapsed before the first molt. Under favorable conditions of temperature larvæ in this stage remained three days without molting. In molting he noted that the skin was shed from the head and posteriorly, and that not only the skin was shed, but also the cephalopharyngeal sclerites, as well as the chitinous lining of the fore portion of the alimentary tract. He observed that the second stage of the larvæ

might last only twenty-four hours, but at a lower temperature or with a deficiency of moisture the period was prolonged and might take several days. The third stage occupied as a rule between three and four days.

At all times the larvæ are very active. When their breeding place is disturbed they wriggle actively about in the endeavor to conceal themselves, and so rapidly do they accomplish this purpose that it is difficult to take a satisfactory moving picture of them, or indeed a photograph of any kind. When full-grown and ready to transform, the yellowish color becomes more pronounced, owing to the proliferation of fat cells in great numbers in anticipation of the resting, non-feeding pupal condition. The transformation to pupa may take place almost anywhere, but as a rule there is an effort on the part of the larvæ to descend deeper into the manure pile or other substance in which they may be living, and sometimes, when the substance upon which they have fed is moist and the earth below it is also moist and easy of entrance, they may descend two or three inches below the surface of the ground.

The only good word that can be said for this fly is the fact that its larvæ destroy enormous quantities of excrementitious and waste material, greatly assisting the bacteria of putrefaction. E. Guyénot (1907) shows, first, that the liquefaction of albuminoid substances is the result of a true process of digestion under the influence of certain germs of putrefaction; second, that fly larvæ, absorbing exclusively liquid substances, easily assimilable, have the digestive tract

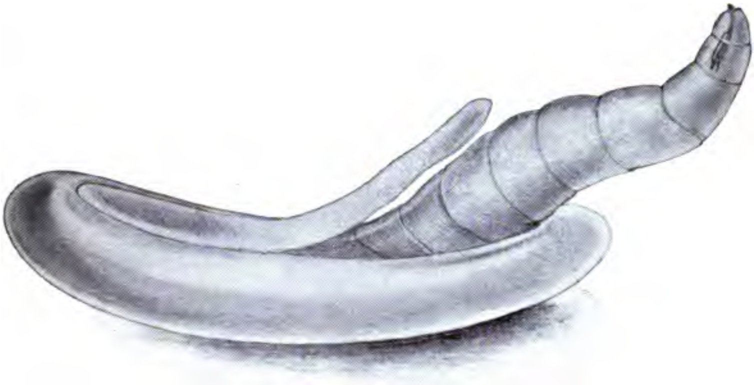

Fig. 6.—Egg hatching; greatly enlarged. (Original.)

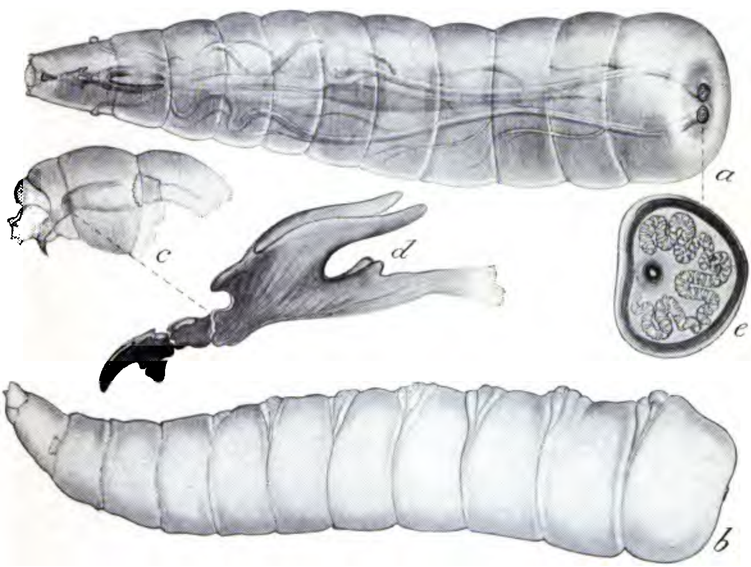

Fig. 7.—Full grown larva of house fly; greatly enlarged: *a*, anal spiracle; *b*, side view of larva; *c*, cephalo-pharyngeal skeleton; *d*, same; *e*, anal spiracle still more enlarged. (Original.)

reduced to the minimum and do not produce soluble ferments in appreciable quantity; third, that the larvæ accelerate putrefaction of bodies by assisting in the increase of microbes; fourth, that the larvæ nourish themselves at the expense of the products of germ chemistry—the germs can develop rapidly and spread in all directions only by the assistance of the larvæ; there exists between these two agents of putrefaction a true symbiosis. These conclusions, although reached by a study of two species of the genus Lucilia, are undoubtedly applicable to the larvæ of other flies feeding in animal material.

The Pupa and Puparium

Before beginning its transformation to the pupa, the full-grown larva empties its alimentary canal, contracts from its own skin, the skin itself forming a nearly cylindrical pupal case, the posterior portion being slightly larger in diameter than the anterior and both ends being equally rounded. It is then about six mm. in length and of the shape shown at figure 11. At first this pupal skin remains pale yellowish, but rapidly changes to red and finally to a dark chestnut color. The insect inside loses its tracheal system, which is withdrawn by the surrounding skin and eventually remains inside of the skin or pupa shell but outside of the insect itself. The insect rapidly assumes a true pupal shape, and at the end of thirty hours, according to Doctor Hewitt, most of the parts of the future fly can be distinguished, although they are sheathed in a pro-

tecting nymphal membrane. A fully formed pupa taken from the pupal sheath, or puparium as it is called, is shown in figure 11.

In this stage in Washington in midsummer the writer has shown the normal duration to be about five days. Mr. Newstead gives the period as from five to

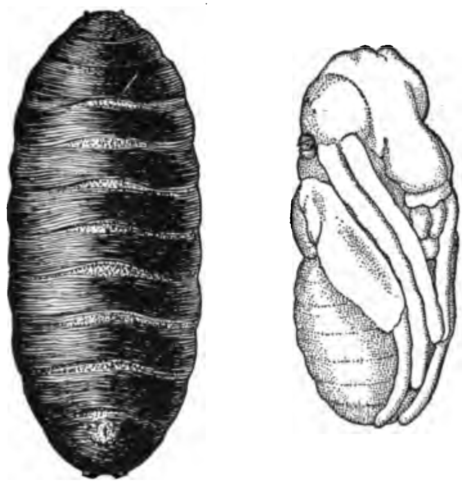

Fig. 11.—House fly puparium (at left) and pupa (at right); greatly enlarged. (Original.)

seven days in cases where there is heat produced by fermentation, but where there is no such heat the stage may last from fourteen to twenty-eight days, or even considerably longer. Doctor Hewitt states that with a constant temperature the adult flies may emerge between the third and fourth day after pupation, but that the period is more usually four or five days, since the larvæ when ready to pupate as a rule leave the hotter

Fig. 8.—Larvæ in horse manure. (From Newstead.)

Fig. 9.—Larvæ and puparia. (From Newstead.)

portions of the substance in which they have been feeding and transform in the cooler portions. He suggests the idea that this migration outward may be a provision for the more easy emergence of the fly when the time should come. In some cases he found that the pupal stage lasted through several weeks, but he was never successful in keeping pupæ through the winter. Mr. Newstead found that in stable middens the puparia occur chiefly at the sides or at the top of the wall or framework of the receptacle where the temperature is lowest. He found them in such situations often packed together in large masses numbering many hundreds. In ash pits he found the same conditions.

Where the manure is in small piles, or is partly spread out, the full-grown larvæ almost ready for transformation are apt to migrate into the loose ground under the pile or from the edges of the pile outwards, to transform under nearby rubbish. This habit may have a very important practical value, since municipal regulations of individual stable practice in regard to the removal of manure should take into consideration that such removal at intervals longer than those required for the larva to reach full growth may result in the leaving of many puparia, except of course in cases where especial receptacles for manure are in use.

Emergence of the Adult

This has been well described by Doctor Hewitt as follows:

"When about to emerge, the fly pushes off the an-

terior end of the pupal case in dorsal and ventral portions by means of the inflated frontal sac, which may be seen extruded in front of the head above the bases of the antennæ. The splitting of the anterior end of the pupal case is quite regular, a circular split is formed in the sixth segment and two lateral splits are formed in a line below the remains of the anterior spiracular processes of the larva. The fly levers itself up out of the barrel-like pupa [puparium] and leaves the nymphal sheath. With the help of the frontal sac, which it alternately inflates and deflates, it makes its way to the exterior of the heap and crawls about while its wings unfold and attain their ultimate texture, the chitinous exoskeleton hardening at the same time; when these processes are complete the perfect insect sets out on its career."

The frontal sac just mentioned is the distended membranous portion of the front of the head. This is constantly distending as the fly walks rapidly about after issuing. When it is contracted at this early time, it forms a dull area, soft and fleshy-looking, and free from hairs. The fly possesses the power of distending it into a bladder-like expansion, trapezoidal in outline and almost as big as the rest of the head, pushing the antennæ down out of sight. This membrane is evidently distended with air, and, as pointed out by Packard, its connection with the tracheæ and the mechanism of its movements would form a very interesting subject of inquiry. Lowne, in his Anatomy of the Blow-fly, has described a similar structure with that insect,

Fig. 10.—Puparia on a bit of old rotting cloth from an ash barrel. (From Newstead.)

and he is obviously correct in supposing it to be a provision for the pushing away of the end of the puparium when the pupa emerges from its case. This frontal sac has been noticed by many observers, and was well described as long ago as 1764 by Count von Gleichen.

Structure of the Adult

In the section on zoological position, a description has been given of the characters which separate the adult typhoid fly or house fly from other allied or similar flies. The excellent illustrations given here (figures 12 and 13) show in more or less detail its exact structure. Especial attention should be called, however, to the character of the mouth parts and of the feet. The whole insect is more or less bristly and well capable of carrying micro-organisms from putrescent or semi-liquid substances, but the mouth parts and the feet are especially adapted to this purpose. In addition to two claws, each of the six feet is supplied with two sticky pads of a light color. These are called pulvilli. On the walking surface these pads are closely covered with hairs which secrete a sticky fluid, and it is by their help that flies are able to walk in any position upon highly polished surfaces.

The mouth parts are very complicated, but form in the main a proboscis which is not fitted for piercing but for sucking and is illustrated so well in figure 15 that detailed description will be unnecessary. This organ can be retracted and expanded to a certain extent. It is somewhat complicated in structure and consists

of an upper and a lower portion, the upper portion bearing two curved bristly lobes. The lower portion or true haustellum expands at the tip into two lobes which are called the oral lobes. On their under surface they have transverse chitinous bars which are called false tracheæ (pseudotracheæ). The presence of these hard ridges under the oral lobes fit it to a certain extent for rasping solid food. The orifice to the haustellum occurs between the lobes.

In feeding upon fluid or semi-fluid substances, the oral lobes are simply applied to the surface and the fluid is sucked up. When, however, they feed upon soluble solids the process is somewhat different. Doctor Graham-Smith has carefully watched them feeding upon crystals of brown sugar, and has done this through the Zeiss binocular microscope. He states that the oral lobes of the proboscis are very widely opened and closely applied to the sugar. Fluid (saliva) seems to be first deposited on the sugar and then strong sucking movements are made. Doctor Graham-Smith watched a fly sucking an apparently quite dry layer of sputum. It put out large quantities of saliva from its proboscis and seemed to suck the fluid in and out until a fairly large area of the dry layer of sputum was quite moist; then as much as possible was sucked up and the fly moved away to another spot. The same observer noticed that flies which had the opportunity of feeding either on fluid or partly dried milk often chose the drier portions, and states that under natural conditions they can often be seen sucking the dried

remains near the top of a milk jug. They constantly apply their mouth parts to the surface over which they are walking, attempting to suck up some nutrition, and under certain conditions the imprints of their oral lobes can afterwards be made out under the lens.

In order to understand the digestive processes of a fly and to comprehend fully just what a disease germ

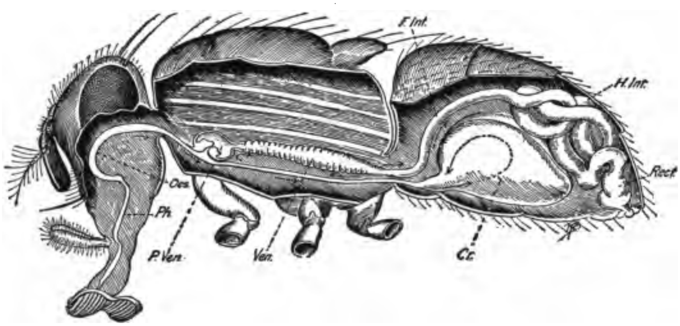

Fig. 16.—A diagrammatic figure of the alimentary canal of the house fly; greatly enlarged. *Ph.*, Pharynx; *Oes.*, Esophagus; *P. Ven.*, Proventriculus; *Ven.*, Stomach; *F. Int.*, Fore intestine; *H. Int.*, Hind Intestine; *Cr.*, Crop; *Rect.*, Rectum.

passes through after it is sucked up by one of these creatures, it is necessary to know something of the structure of the alimentary canal. This is simpler with the house fly than with many other flies, more so in fact than that of the blow fly, whose anatomy was so carefully worked out by the famous English microscopist, Lowne. It consists of a pharynx, a rather narrow esophagus, a proventriculus or chyle stomach, a crop, a ventriculus or true stomach, a fore and a hind

intestine. The proventriculus is a nodular structure with muscular walls and probably acts also as a pumping stomach. The food, passing through the esophagus into the proventriculus, immediately goes by an almost continuous route into the crop. The tube leading into the crop leads out from the proventriculus on the under side backwards and ends in the crop itself, which is a double organ situated in the lower part of the abdomen of the fly. This crop is really a temporary storehouse for the fly's food, and in this storehouse it remains practically unchanged, as has been proved by exact experimentation. Returning from the crop, possibly pumped back by the muscular walls of the proventriculus, it recedes again into the true stomach or ventriculus, which is a somewhat expanded tubular organ running fore and aft and situated above the tube leading to the crop. The stomach proper extends back through the thorax under the big muscles of the back and into the abdomen, where it ends just over the point where the crop begins to dilate. It runs into the rather narrow fore intestine, which convolutes upon itself four or five times, and ends in the hind intestine, which in turn ends in the rectum. The intestine is called the hind intestine from the point where the Malpighian or urinary tubules enter.

Naturally the structure and function of the crop and the proventriculus are matters of considerable interest in considering the distribution of disease germs by flies. As Graham-Smith points out, the crop is first distended with liquid food at the beginning of a meal,

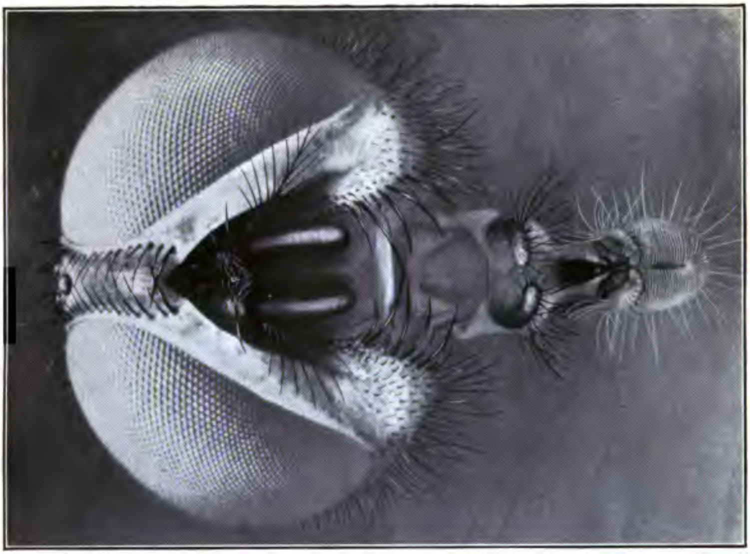

Fig. 14.—Head of adult house fly; greatly enlarged. (Photograph by N. A. Cobb. Copyright by National Geographic Society of Washington, D. C.)

Fig. 15.—Head of adult house fly from side; greatly enlarged. (Photograph by N. A. Cobb. Copyright by National Geographic Society of Washington, D. C.)

and, if after this the fly continues to feed, the food may pass directly into the true stomach through the chyle stomach. If the fly is disturbed before any of the food has entered the stomach, the food which has been sucked into the crop is gradually passed into the stomach. Eventually the contents of the crop get into the intestine. The proventriculus seems to act also as a valve and be capable of closing the orifice into the stomach so that the food shall all pass into the crop. When the crop is fully distended it opens so that food can pass directly into the stomach, and naturally also opens later to allow the food to pass from the crop forward and back.

Careful observations made by this author indicated the rate at which food passes from the crop into the intestine, in which he showed that, using colored fluid, after three minutes the crop was full of red fluid, but none was found in the stomach or intestine. After ten minutes the fluid was just beginning to pass into the stomach. After fifteen minutes the crop was still full and the upper third of the stomach was full. After two hours in one case the crop was still full and the upper three-fourths of the intestine was full. Other observations indicated that the crop may remain full, after a single feeding, for as long as four days, thus acting as a storage reservoir against any possible scarcity of food.

Some interesting observations were also made by the same author on the habits of flies after feeding on different fluids. These observations were made in cages,

and he found that after gorging themselves they usually climbed up the sides of the cage and moved from place to place, often stopping to rub one leg against another or to clean themselves by passing the legs over their heads and wings. At intervals he noticed that they sat still and regurgitated large drops of liquid from the tips of their beaks. He showed that the drops gradually enlarged until they were about equal in size to the head of the fly. Sometimes the drop was deposited, sometimes slowly withdrawn, and this occurred several times. When disturbed, the drops were deposited or withdrawn with great rapidity. Flies were often seen to suck up the drops deposited by other flies. It is these regurgitated drops which make the larger stains upon a window covered with fly-specks.

Attention should be called to the shape of the compound eyes of the fly, and it will be noticed that they are so situated that a fly can see in all directions at the same time.

Difference in Size of Adults

There is a considerable difference in the size of the adult winged flies, but this by no means signifies that small adult flies grow into large ones. This is a widespread popular fallacy. The writer once in his younger days attended a meeting of the Philosophical Society of Washington to listen to a paper by the late C. V. Riley on some phases of insect life, in the course of which the house fly was incidentally mentioned. With his entomological training, he was amazed in the dis-

cussion which followed to hear one of the most eminent of America's scientific men (an astronomer, by the way) ask Professor Riley, "It is true, of course, is it not, that the little flies one occasionally sees on the window-pane grow and become the large flies that are so numerous?"

No fly, after it issues from the puparium, grows at all; no insects grow after the last molt; in fact, insects can grow only by casting their skins, and none of the insects having what is called a perfect metamorphosis casts the skin after reaching the imago or winged stage.

But some typhoid flies are larger than others, and the explanation is a different one from that of the growth of the winged form. The same thing is seen with other insects, and it results as a rule from the amount of larval food; certain larvæ stinted in their supply of food transform to pupæ when small and naturally become small adults. There is a distinct connection with them, as with human beings, in stint and stunt, aside from the similarity of the words and their origin.

With the house fly, however, some exact observations have been made on this point by Griffith (1908) and Packard (1874). Griffith found that when the larvæ were kept cool and the pupæ warm all the flies that came out were small. In fact, he found that it was a rule that cold surroundings, even with plenty of food, produced small flies. And he further states that such small flies are incapable of reproduction. He

points out that small flies are found at the end of summer when it has become cooler, and also in the early spring, the latter having hatched late the previous autumn. The question of the hibernation of flies will be considered in a later paragraph, but in this connection it should be stated that Doctor Griffith secured reproduction in the late autumn and winter, but that all of the resulting flies were of small size, though their larvæ were kept at a warm temperature. The flies from only one of these batches were of normal size, while those in one set were "extremely small, quite pigmies; and these died from no apparent cause, probably from marasmus, after a month." He further states that from the same batch of eggs he has reared large, medium and small flies. Packard (1874) found that those larvæ which were reared in too dry manure were nearly one-half smaller than those taken from the manure heap. No direct warmth and the absence of moisture seemed to cause them to become dwarfed.

The error of deduction made by the famous astronomer was by no means an error of observation, as appears from what precedes, but there are found in houses other flies of entirely different species from the house fly, as will be shown in another chapter. Some of these are considerably smaller, and one of them, the little fly often seen on window-panes (*Homalomyia canicularis*), is very much smaller. In fact, as though to perpetuate the error, the Germans call this last species "die kleine Stubenfliege"—the little room fly or house fly.

Summary of Duration of Life Round

In summarizing the duration of the life round, we find that the writer's Washington observations made the total life round approximately ten days, as indicated in an earlier paragraph. These were midsummer observations made in August, 1895, on the Department of Agriculture grounds in the city of Washington, but in a warmer climate they may be hastened even beyond this minimum. Thus, in India Surgeon Major F. Smith, of the Royal Army Medical Corps, found at Benares that from a collection of one day's fresh droppings of three horses the adult *Musca domestica* was obtained on the eighth day after the laying of the eggs, thus shortening the period considerably. Moreover, Doctor Hewitt's minimum rate of growth was: egg, eight hours; first-stage larva, twenty hours; second-stage larva, twenty-four hours; third-stage larva, three days; pupa, three days—a total of eight days and four hours, surely a much shorter period than often happens in England, although the occasionally high summer temperature combined with the moist climate of that country may occasionally bring about this shortening. Mr. Newstead's observations in Liverpool, on the other hand, show a minimum period of from ten to fourteen days and a maximum of from four to five weeks or longer.

Dr. A. Griffith, Medical Officer of Hove, England (a seaport on the English Channel), experimented with house flies during 1904-7. He gives as the minimum

time in any of his sets of rearings, which he tabulates in *Public Health*, May, 1908, four and one-half to six days from egg to pupa, and three and one-half days from pupa to adult fly, a minimum for the life round of eight days. He found great variations in this period, according to the prevailing temperature.

Number of Generations

Taking the minimum duration of a generation in Washington so far as observed (and this must not be taken as the scientific minimum, since it depends upon observations taken only during midsummer of a single year), or we will say perhaps a midsummer average under Washington conditions, and accepting Doctor Hewitt's observations as to the time elapsing between the issuing of the adult flies and their sexual maturity as being, perhaps under American conditions, ten days, we see that there is time for the development of seven generations between April 15th and September 10th. Flies, it is true, continue to emerge from manure piles and other breeding places much later than September 10th, and in fact during the season of 1910 active larvæ were found as late as the 30th of November, while on the occasional warm days of that period adult flies were still active and laid eggs. The generations of springtime and of autumn, however, are of much slower development than those of midsummer, so that it is probably safe to say that there are seldom more than nine generations a year under outdoor conditions in places comparable in climate to Washington.

Farther south, however, where the summer is longer, and particularly where the climate is moist, there may be more generations than this. In India, for example, where Surgeon Major Smith made his observations showing a minimum rate of eight days to a generation and where the warm spell is very long, an extraordinary abundance of flies in the autumn, with proper conditions of moisture, is a certainty. No wonder that the punkah was invented in India! In the same way, as one goes north the number of generations per year is naturally smaller and the autumnal abundance of flies becomes greatly lessened in consequence. Forbes's assistants in Illinois found the life round in midsummer to vary from nine to fourteen days.

Possibilities in the Way of Numbers

This number of generations has a direct bearing upon the number of flies, not only at different periods during the summer, but also in the early autumn, since there is, barring accidents, a constant and definite and enormous increase. Of course some summers are warmer than others and some are moister than others, and upon these two factors, taken in connection with that of available places for breeding, the number of flies must depend.

Take, for example, the possibilities in Washington, and let us estimate—on the basis of the survival of all eggs and all individual flies—upon plenty of places for the insect to develop and for the larvæ to feed, upon an average of ten days to a generation in midsummer

(this period increasing in the autumn and being greater also in the springtime), and also upon a period of ten days after emerging of the adult flies before sexual maturity is gained (this point of the duration of the existence of the adult fly before the attainment of sexual maturity has been the weak element in other calculations that have been made of house fly abundance) —let us start, then, on April 15th with a single over-wintering fly which on that day lays 120 eggs, and we will have the following table:

April 15th, the over-wintering female fly lays 120 eggs.
May 1st, 120 adults issue, of which 60 are females.
May 10th, 60 females lay 120 eggs each.
May 28th, 7,200 adults issue, of which 3,600 are females.
June 8th, 3,600 females lay 120 eggs each.
June 20th, 432,000 adults issue, of which 216,000 are females.
June 30th, 216,000 females lay 120 eggs each.
July 10th, 25,920,000 adults issue, of which 12,960,000 are females.
July 19th, 12,960,000 females lay 120 eggs each.
July 29th, 1,555,200,000 adults issue, of which 777,600,000 are females.
August 8th, 777,600,000 females lay 120 eggs each.
August 18th, 93,312,000,000 adults issue, of which 46,656,000,000 are females.
August 28th, 46,656,000,000 females lay 120 eggs each.
September 10th, 5,598,720,000,000 adults issue, of which one-half are females.

Such figures as these stagger the imagination. They are apt to make one feel hopeless at the thought of attempting to exterminate or to hold in check a creature

with such possibilities of multiplication; but it must be remembered that in the supposed instance upon which we have figured, all of the eggs hatched and all of the progeny have survived, whereas in nature a fly has many chances of death, not only between the egg and the adult, but as an adult before the period of sexual maturity has been reached. And it is upon this period which must elapse between the issuing of a fly and the time when it shall lay eggs that one of the several excellent plans for the warfare against this species has been based. It must be remembered, on the other hand, that in the table we have assumed that each female has laid only 120 eggs, that is one batch, while in reality she may lay four such batches. The task of estimating the possibilities on the larger basis is left to some reader who likes to multiply. Does not a contemplation of these possibilities, even with all the possible accidents of nature to limit them, indicate in the strongest possible way, even if the carriage of disease by these pernicious creatures were not considered, the necessity of an effort on the part of people to assist nature in limiting a nuisance to humanity?

Number by Actual Count in Relation to Quantity of Food

On August 9th in Washington a quarter of a pound of rather well-infested horse manure was taken from a manure pile, and in it were counted 160 larvæ and 146 puparia. This would make about 1,200 house flies to the pound of manure. This, however, cannot be taken

as an average, since no larvæ are found in perhaps the greater part of ordinary horse manure piles. Neither, however, does it show the limit of what can be found, since on the same date about 200 puparia were found in less than one cubic inch of manure taken from a spot two inches below the surface of the pile where the larvæ had congregated in very great numbers. This, as stated, was in August and the height of the fly season had not yet been reached. Major N. Faichnie, of the Royal Medical Corps, in the Journal of the Royal Medical Corps for November, 1909, gives the result of certain experiments with flies, indicating that in India he reared 4,000 flies from one-sixth of a cubic foot of trench ground. He also states that he reared 500 flies from one dropping of human excreta.

Further counts have been made by Dr. W. B. Herms, of the University of California (1910). Doctor Herms took four samples from different parts of an average horse manure pile in Berkeley, Cal. (not near a livery stable). The four samples weighed fifteen pounds in all and contained by actual count 10,282 larvæ, nearly all of which were nearly or quite full grown. The weight of the entire manure pile was estimated at 1,000 pounds, and, at the rate counted, estimating that possibly one-third of the pile was uninfested, the pile contained 455,000 and more larvæ. Is it any wonder that flies swarm near the average stable?

Hibernation

The typhoid fly apparently suddenly disappears with the first sharp frost. It will reappear later on the warmest days. With a great reduction of the temperature of their breeding places, many larvæ are killed, and eggs as well. Whether the pupæ in their tight puparia are destroyed by a certain degree of cold does not seem to be known. The adult flies undoubtedly linger in warmed houses throughout the winter, but that enough of them remain in active condition in such locations to perpetuate the species and to start the rapidly multiplying generations of the following summer seems doubtful. The adult flies undoubtedly remain dormant even in warmed dwellings, and it is altogether likely that some of them remain dormant throughout the winter months in sheltered but cold situations. Many adult insects pass the winter in this way, and observations have been made which indicate that this is the case with the house fly, although as a matter of fact sufficient attention has not been paid in the observations on record of the exact specific identity of the flies in question. As has been pointed out before, there are so many species of flies which so exactly resemble the typhoid fly to the macroscopic eye that any one may be pardoned for stating that house flies have been seen tucked away carefully in cracks, when a microscopic examination would have shown that some other species was concerned.

The best observations on this general subject which

have been published are those made by Mr. F. P. Jepson, research student in medical entomology, Cambridge University, England. According to Mr. Jepson (1909), when the frosts come and the cold weather begins in earnest, unprotected flies are probably killed. Those which have found the shelter of some place like a kitchen or a restaurant or a bake house, where the artificial temperature is sufficient unto their needs, continue to live actively; and will even breed when conditions are favorable. He states that some flies possibly exist in dormant condition in such protected localities as behind pictures and loose wallpaper. He found sluggish specimens behind books on a bookshelf in December and January and observed them for some time, finding them in the same positions and still living a month later. His observations ceased at the end of January, but he saw no reason why they should not live on until spring and then begin to breed. In the course of his experiments he found that the flies occurring at the close of the year are much more hardy than those occurring in summer. This fact was experimentally proved, as will be shown later. He further states that one of his friends found flies, presumably typhoid flies, to issue in large numbers from the empty frame of an old window which was removed during the winter.

Jepson experimented with the early stages, and, knowing the idea that possibly the puparia hibernate, he attempted to carry 200 pupæ through the winter, but without success.

The most interesting part of his experimental work,

however, was with 200 flies captured in February flying about in the sculleries and kitchens of one of the colleges at Cambridge. They were quite as active as in the summer. The kitchens are underground, and the fires are kept up continuously. The temperature varied from 65° F. in the mornings to 80° F. in the evenings, and the flies, although somewhat sluggish in the morning, became active when the fires were poked up. The 200 flies under experimentation were transferred to a greenhouse, which was kept in a similar temperature to the kitchens where they were captured, and were kept in closed vessels with a supply of moist bread beginning to ferment. It is worthy of note, by the way, that he found that on several occasions the flies would not lay their eggs upon bread which had not begun to ferment. After the flies had been confined twenty-four hours they laid their eggs, and on the following day all of the eggs hatched. As the bread became moldy the larvæ avoided it, and were transferred to other enclosures and fed upon stale bread slightly moistened. They fed until full grown, then crawled away from the moisture and transformed to pupæ under pieces of newspaper. At a temperature ranging between 65° F. and 75° F. in February, the entire duration of the life round occupied three weeks.

It thus appears that under artificial heat conditions the typhoid fly, given food for its larvæ, will continue to breed almost as rapidly as during the summer time.

Mr. Jepson's observations on the length of life of the adult flies in the winter time further support the

idea that the species constantly hibernates in this condition. Upon the emergence of the adults which he reared in confinement in February, they were transferred to a large net cage and were kept alive successfully for eleven and one-half weeks. The original flies caught in the kitchens in February were kept in captivity for ten weeks. How long they had lived before capture, of course, was unknown, but presumably since the previous autumn. The question of the length of life of the adult fly under all conditions will be considered in a later paragraph.

Habits of the Adult Fly

On issuing from its pupal sheath, the first impulse of the adult fly is to feed. After its rest in the pupal condition, during which time it has taken no food and has subsisted by the physiological consumption of the fat cells stored up during the last larval period, it has naturally become hungry, and it flies immediately to the first point offering sustenance. The sense of smell of the typhoid fly must be very keen, although its selection of attractive odors undoubtedly differs from our own. It is very catholic in its choice of food—the milk jug and the freshly baked custard pie are apparently equally in favor with the slop bucket, the garbage pan, and all sorts of unmentionable filth. It knows the odor of cooking, and it flies unerringly towards the nearest kitchen, although here the temperature of the kitchen stove may attract it almost as much as the possibility of something good to eat. As has been shown in our

brief discussion of the mouth parts of the adult fly, its food must be liquid, and when it alights upon a solid a plentiful flow of a salivary liquid enables it to make some slight impression and to gain sustenance. Thus it drinks as well as eats, and liquids apparently containing little that will help it to exist are sought by it, but it especially prefers semi-liquid mixtures. Every one who reads this book knows how in the old days, and even now in some places, the typhoid fly swarmed or swarms in a certain class of public restaurants and in poorly cared-for eating places. The story of the man who entered a dimly lighted railway restaurant and asked for "a piece of that huckleberry pie" and was informed that it was not huckleberry but custard, is literally true. Dr. Theobald Smith phrased it very happily in a paper written a few years ago in the following words: "When we go into a public restaurant in midsummer, we are compelled to fight for our food with the myriads of house flies which we find there alert, persistent and invincible." Doctor Smith has been very fortunate in the choice of the word "persistent." The typhoid fly does not seem to have any common sense. At one time he is alert, to use Doctor Smith's word, and it is impossible to catch him, but his persistence even in the face of imminent danger is one of his characteristics which is most impressive. When one lies drowsily in bed of a summer morning with but one fly in the room, "persistence" is the only word to apply to its annoying return again and again and again to the face of the sleeper in spite of repeated slaps. Here

it is the perspiration which attracts the fly. It is hungry and thirsty and wants food and drink.

The typhoid fly is a diurnal species. It rests during the night. It is not especially fond of the bright sunshine, and if one stays in direct sunlight he is not often troubled by it. But it revels on the shaded porch and in the lighted house away from the sun's direct rays. It flies into the dimly lighted stable in search of places to lay its eggs, but in absolute darkness and even in darkness which is not absolute it rests immovable. Its resting position seems to be a matter of indifference to it; it can sleep equally well on the ceiling or on the side wall. It does seem to have some preference for anything hanging perpendicularly, such as an old-fashioned rod supporting a candelabrum or a central gas fixture or a window-curtain string, and this observed preference has been taken advantage of by the inventors of certain fly traps which consist of a suspended strip of sticky paper.

Reverting once more to the feeding of the adult fly, a correspondent whose name the writer has unfortunately forgotten described an instance where he had left a blood-stain on a slide at which a house fly subsequently sucked. On examining it afterwards under the microscope, the fly, he found, had taken up all of the red blood corpuscles and had left all of the white.

Flies are great feeders. Where food is abundant they will suck at it almost continuously or at very brief intervals. As indicated elsewhere, the alimentary canal is comparatively simple, the digestive processes seem

of the simplest and the food passes through the body with the greatest facility.

Do Flies Have a Color Preference?

Galli-Valerio (1910) states that the French agricultural journals have published a statement that Fé, having observed that flies do not rest upon walls covered with blue paper, blue-washed the walls of his milk stables and that the flies then disappeared, and asks the question whether a similar method could be used to keep flies out of houses. He himself conducted experiments with a box having glass walls, 35 × 35 × 35 cm. in size, and pasted on the walls bits of paper all the same size but of different colors, and afterwards introduced a certain number of house flies. For several days, after turning the cage in different positions so as to avoid error from other causes, he counted the flies which were standing on the different colors. The results were as follows:

Clear green	18	Dark green	5
Rose	17	Red	4
Clear yellow	14	Orange	3
Azure	13	Clear brown	3
Clear red	10	Pale rose	3
Dark gray	9	Very clear green	2
White	9	Blue	1
Dark red	8	Pale violet	1
Black	7	Dark brown	1
Pale gray	5	Lemon yellow	1
Dark yellow	5		

The observer noted that eighty-seven flies stood on the clear light colors, and fifty-two on the dark. Blue

was surely one of the colors least visited, but on the contrary azure was one of those most frequented. He thinks that possibly after all it was only a chance, but is of the opinion that Fé's observation should be the basis of an experiment on a large scale with the same ultramarine blue which he employed. It seems doubtful, however, that a cold, hungry fly will be kept from a warm, odoriferous kitchen by the bluest of blue colors.

Fly-specks

Since, on account possibly of the simplicity of the digestive processes just referred to, pathogenic bacteria and other micro-organisms pass unchanged through the alimentary canal of the typhoid fly, the question of fly-specks becomes one of great importance. Every casual observer knows that they are laid with great frequency, and that when flies are abundant their specks are to be found everywhere. Curiously enough, few exact observations have been made upon the frequency with which the fly deposits its excreta. Major N. Faichnie, previously referred to, working in India, found that when a fly is put in a clean paper box it passes its excrement fifty times in twenty-four hours; that is to say, about once every half hour; but he neglects to state whether there was food in the box. Presumably there was some food, and also presumably there was not much of a semi-liquid character. Cobb (1910) gives a table of the intervals between defecation of a *well*-fed fly, together with notes on the spores in the excreta. One naturally infers, from the title of the

article, that the fly in question was a house fly, but upon consulting an important paper by the same author (1906), entitled "Fungous Maladies of the Sugar Cane," the same table is found printed on page 64 and the fly in question is said to be a Sarcophagid, and therefore not *Musca domestica.* In his opening paragraph in the 1910 article, Doctor Cobb explains, "In some of these paragraphs, however, the statements are inferences fully justified by experiments with very similar species," and this table is evidently one of these inferential statements. It is not safe to state that because, as shown in the table, a well-fed Sarcophagid fly will defecate on the average once every four and one-half minutes, from half past nine until half past eleven, a true Musca will do the same. It is by no means impossible that it will do so, but unfortunately we have not the proof. Still with this explanation it will be interesting to state that in the interval between 9:35 and 11:26 the fly observed by Doctor Cobb (it had been fed at 9:23) made twenty-three fly-specks at intervals varying from one to fifteen minutes, an average of about four and one-half minutes; and in ten of these twenty-three specks Doctor Cobb found spores. Herein lies one very great danger from flies. Certain authors believe that the danger from disease germs that pass through the fly's body in this way is greater than from those that are supposed to be carried from foul substances on its feet.

With the abundance of flies in the late summer, the number of fly-specks becomes almost unlimited. Doc-

tor Cobb states that he possesses actual counts made by the use of a little counter of his own invention, but that he does not publish these records for fear that he will be accused of sensationalism. He says that window-panes with from 1,000 to 10,000 fly-specks per square foot are not at all uncommon, and that from ten to fifty per square foot is a common number in what are considered well-kept homes. And this is only in places where the dirt can be readily seen. He states that on neutral-tinted objects which are not cleaned so frequently fly-specks occur in millions. "On wallpaper, chandeliers, outside veranda posts, on cornices, ceilings, and window blinds, the numbers are almost past computation." He further shows that examination of the excreta of flies captured in the open shows that they contain a great variety of spores in living condition. He finds that the digestion of the fly consists simply in the absorption of those substances readily soluble in its weak digestive fluids and the evacuation of all others; therefore the fly is an enormous feeder. Doctor Cobb states that in a single meal it frequently swallows nearly half of its own weight of food. This accounts for the frequency of the fly-specks, and, considering the number of flies, for the enormous number of specks.

Doctor Graham-Smith, elsewhere quoted, made a few studies of the number of deposits left by flies. He found that the rate at which the deposits are produced depends upon temperature and the form of food, flies being most lively in hot weather or when placed in a

warm incubator. He fed three lots of flies on syrup, milk, and sputum, respectively, for several days, and noted that those fed on syrup produced an average of four and seven-tenths deposits per fly per day, those on milk eight and three-tenths and those fed on sputum twenty-seven. In the latter case he states that the feces were much more abundant and liquid than usual, and that in fact the flies seemed to suffer from diarrhea. In another series of experiments ten flies were given a single feed of milk and then transferred to fresh cages. They deposited either by regurgitation or as excrement forty-one spots in the first hour, sixteen in the second and third, twenty-four in the fourth, twenty-four in the fifth, and fifty-nine in the prolonged interval between the sixth and twenty-second hour. With another series of eleven flies, milk was always present in the cage so that the flies could feed as often as they wished, and here thirty-two spots were made in the first hour, forty in the second and third, ten in the fourth, eighteen in the fifth, and 134 in the sixth to the twenty-second hour; making a total of 164 spots from the ten flies that had had but one feeding and 224 from the eleven flies which had the milk continuously in their cage.

Distance of Flight

Prof. S. P. Langley, the late Secretary of the Smithsonian Institution, was, as every one knows, greatly interested in the problem of aeronautics, and his experiments with flying machines heavier than air prac-

tically made him the first successful investigator in this direction, since the Wright brothers acknowledge that they owe very much to Langley's scientific papers on this subject. From his interest in this direction, Professor Langley devoted certain grants from the so-called Hodgkins fund* to the study of the mechanism of flight of various birds and insects. Some of the results of these studies have already been published in the Smithsonian Miscellaneous Collections. During the past ten years a series of these investigations have been carried on under Prof. Robert von Lendenfeld of the University of Prague, and from a report received from Professor von Lendenfeld by the present Secretary of the Smithsonian Institution, Doctor Walcott, which the writer has been permitted to see, it appears that, after a study of the organs of flight in the Lepidoptera, Hymenoptera, and Diptera by Messrs. Hauptmann, Gröschl, Ritter, and Professor von Lendenfeld, the latter became convinced that of all the forms of insects, and indeed of all flying animals, the Diptera would furnish the best models for flying machines. He thinks that a model built according to this pattern should be made and experimented with. Certain studies by Mr. Ritter on the blow fly, which are at the time of this writing in the hands of the Smithsonian Institution for publication, indicate that this insect and its flight would form the best basis for a model.

This is an interesting and important statement, since

*A bequest to the Smithsonian Institution for the investigation of the properties of the upper air.

it has been made after a long series of comparative studies, and its truth will readily be admitted by any one who has paid much attention to the flight of Diptera. Cobb, in his paper on the Fungous Maladies of the Sugar Cane, records a number of observations on the flight of flies in connection with the distribution by the flies of the spores of a fungous disease of sugar cane. He states that he never succeeded in tiring his flies very perceptibly if they had a free space to move around in. When confined in a room they were kept on the wing for hours without showing much fatigue. By dissection he showed that with certain of the Sarcophagid flies the thoracic or wing muscles constituted twenty-six and two-tenths per cent. of the weight of the fly, and that the mass of the great thoracic muscles is proportional to the apparent power of flight among different flies. He records also a remarkable example of the power of flight of one of the larger flies. On a voyage across the Mediterranean from Algiers to Marseilles, he observed a Dipterous insect keeping pace with the steamer "so accurately that it almost seemed as if it were joined to the boat by some invisible rigid connection. The boat left Algiers at noon and as long as there was any light left by which to observe, the insect kept its place steadily. This was in midsummer. The insect never made any attempt to come aboard. The boat was not particularly fast, her speed being about thirteen knots."

Every one who has driven a fast team of horses over a road through pine timber must have noticed the ex-

traordinary flight of the gadflies of the family Tabanidæ, which for hours will circle about the horses, flying with ease much more rapidly than the speed of the vehicle, alighting only occasionally. It is not intended to convey by these instances the impression that it is known that the house fly is at all extraordinary as a flier among the Diptera—in fact, when the truth is fully known it may be shown to be comparatively a weak flier among its relatives; but it darts here and there through the air with great speed, and if it were obliged to fly great distances the writer has little doubt of its ability to do so.

The practical question involved in the distance of flight, however, is the one of protection of food supplies at a distance from fly breeding places which cannot be controlled. Will the proper care of the stables and houses in a given city square relieve the houses in this square from the fly pest to a measurable degree, provided stables and houses one square or two squares away remain uncared for? The situation must be much as it is with mosquitoes, although the house fly is a much stronger flier than any mosquito. The house fly will seldom travel very much farther than it has to fly for food and a proper nidus for its eggs, but as a matter of fact it is very difficult to prove this. Further experimental work should be carried on in this direction.

J. S. Hine (*in lit.*) states that in the summer of 1910 he made an effort to determine the distance that flies travel. At a barn where he was carrying on some work

he captured some 350 flies and marked each one's wing or thorax with a small spot of gold enamel. Flies so marked were repeatedly observed about dwellings from twenty to forty rods from the barn up to the third day, but in a dwelling house a half mile away none of the marked specimens was detected. This, however, was a very unsatisfactory experiment, because it does not in the least show that if the dwellings twenty to forty rods from the barn had not existed flies would not have been found in the dwelling half a mile away. As Hine himself states, "It appears most likely that the distance flies may travel to reach dwellings is controlled by circumstances. Almost any reasonable distance may be covered by a fly under compulsion to reach food or shelter. Where these are close at hand the insect is not compelled to go far, and consequently does not do so."

Hewitt is of the opinion that normally house flies do not fly great distances, and compares them to domestic pigeons which hover about a house in the immediate neighborhood. He states that they are able to fly, however, for a considerable distance and can be carried by the wind. At one time when he was visiting the Channel Islands he found the house fly from one and one-half to two miles from any house or any likely breeding place that he was able to find. He mentions some exact experiments made by Dr. M. B. Arnold at the Monsall Fever Hospital, Manchester, where 300 flies were captured alive and marked with a spot of white enamel on the back of the thorax. They

were liberated in fine weather, and out of the 300 five were recovered in fly traps at distances of from thirty to 190 yards from the place of liberation, and all within five days. He further states that he had found them at an altitude of eighty feet above the ground, and calls attention to the fact that such a height would facilitate their carriage by the wind.

An experiment made under the direction of Prof. S. A. Forbes, of which he has sent me a written account, indicates that house flies may spread naturally for at least a quarter of a mile, going, in one significant instance, from the tuberculosis hospital to the general hospital of Cook County, Illinois. House flies trapped at one point were sprayed with a chemical solution and liberated. Then flies caught on fly paper elsewhere were sprayed with another solution, the result being that those which had previously been sprayed were turned dark blue in color by the second solution.

Marking Flies for Experiment

Professor Hine found that it was a very difficult matter to mark flies so that they might be recognized from others, since they are very sensitive to anything unusual, and any foreign substance on their bodies or wings causes them to act abnormally. They continually try to remove the foreign substance and seem to tire themselves out. He found that many specimens marked with the greatest care would hardly fly after they were marked, so that it was easy in many cases to approach them and pick them up with the fingers. He

is of the opinion, therefore, that marked flies are likely to be abnormal and are not fit for purposes of exact experimentation. He found that it was impossible to clip off the wing extremity and not inconvenience the flight.

On this subject of marking, Mr. J. P. Jepson, of Cambridge, England, conducted some interesting experiments during July and August, 1908, under the direction of Professor Nuttall. He first tried ordinary household flour, but the flies soon rid themselves of it. This substance was used on account of the observation that flies seen in mills often seem quite white in color. Rice starch powder was next tried, with no success. They were finally marked with ordinary colored blackboard chalks which were finely ground up in a mortar and dusted on the flies until they were completely covered. They tried to clean themselves, beginning with the eyes, but never succeeded in removing the chalk from the upper portion of the thorax or from the base of the wings. Further experiments were tried with aniline dyes either made in the form of a powder with rice starch or mixed with alcohol in the form of a spray. Then again shellac was mixed with the alcohol in order to make the color sticky. In his summary he found that the use of various aniline dyes did not prove satisfactory; with fuchsine the mortality was very large. He found that dusting with rice starch powder and then spraying with shellac and alcohol give an excellent color, but decided that the flies must be allowed to clean their eyes before spraying and that

the spray must be thinly applied. The best result reached by this method was ten days. The reverse, namely, spraying with alcohol and shellac and then dusting with rice powder, was satisfactory where the shellac was not applied too thickly. Colored chalks gave very satisfactory results, yellow and brick red being the best; the yellow lasting for nine days and the brick red for twenty days.

Length of Life of the Adult

It seems that in midsummer the adult flies do not live long, and it is extremely difficult to keep them for any length of time in an enclosure, which, of course, is the only true way of ascertaining exact age. At this time of the year, flies die rapidly in confinement. In June, 1898, the writer was unable to keep alive flies collected at large and placed under a gauze enclosure three feet cube for more than three days, but of course this experiment meant nothing, since the age of the flies collected was not known. Mr. Hine is convinced that flies do not live a great many days in warm summer weather. Marked flies in his experiments in August were not to be found after the third day, and in his experiments with individuals, in confinement with all necessary food, he was unable to keep them alive for more than twelve days. He mentions an instance where on a farm at Ira, Ohio, a pile of infested manure at the barn was hauled up and spread in a field a quarter of a mile away on August 15th; the occupants of the house stated that there was a notable reduction in the

number of flies by August 20th. Major N. Faichnie, referred to above, in experimenting with flies in India in the summer, found that they lived eleven days only. Mr. Jepson, in his notes on the breeding of the common house fly during the winter months, incidentally mentions the fact that during the summer of the previous year (1908) in no case was he able to keep flies alive for more than three weeks, and then only with a few individuals; whereas, as previously stated, flies reared during the winter were kept alive for eleven and one-half weeks, and flies caught in kitchens in February were kept alive for ten weeks and had presumably been living since the previous autumn.

If we take Jepson's statement of three weeks as being the probable limit of the life of the adult fly in midsummer, and if we conclude, as we must, that the average life at that period is much shorter than this, it becomes evident from what will be stated in the following paragraph that after the female fly has laid her eggs in summer she has not much longer to live. The plain inference from this will naturally be that the hibernating flies in the winter time are probably for the most part females which have not laid their eggs. Unfortunately for the conclusions just stated, Doctor Hewitt records the fact that he has kept flies in captivity in the summer time for seven weeks, while Griffith (1908) was able to keep a male sixteen weeks.

Ficker (1903), in an account of experiments carried on between June and October, states that he kept flies alive in confinement for four weeks, feeding them on

sugar, bread, water, or milk. Unfortunately he does not give the exact dates of this particular observation, and it may have been on an October generation, which would have hibernated.

Time Elapsing Between the Issuing of the Adult and the Period of Sexual Maturity

The practical value of the determination of this period is very great. If an adult female fly can be destroyed before she lays her eggs, we will have killed not only the actual fly, but 120 to 600 potential flies due in a very short time, and if this female fly can be caught in the early spring the table on an earlier page will indicate that instead of performing a very simple act we have apparently saved the world from almost a calamity. From this can be seen the value of fly traps. Of course the destruction of breeding places is very important, but traps for adult flies are by no means to be despised when we have this idea in view; and the use of fly traps in the early part of the season becomes obviously all-important. The destruction of hibernating flies is equally of value; but these subjects will be considered in the chapter on remedies.

So far as the writer knows, the only observers who have paid any attention to this very important point of the period elapsing before sexual maturity are Hewitt (1910) and Griffith (1908). Hewitt states that he found flies become sexually mature in ten to fourteen days after emergence from the pupal state, and that four days after copulation they begin to de-

posit their eggs; that is to say, from the fourteenth day from the time of their emergence. The experimental data upon which this statement is based are not given in the paper in question, and the writer therefore wrote to him for a transcript of his record, from which it appears that the flies under observation emerged between August 21st and August 28, 1907. They were given fresh horse manure daily, and accurate thermometrical readings were recorded for each of the following days. Not until September 4th was copulation observed, and on September 9th larvæ were found in the manure.

Doctor Griffith, in his observations at Hove, found that the female flies oviposited ten days after issuing from the puparia, and that they could lay new batches of eggs at intervals of from ten to fourteen days until four batches have been laid.

It seems to the writer that this period between issuance and sexual maturity must surely be shorter, and perhaps much shorter, under midsummer conditions and in the freedom of the open air, than that indicated by Hewitt and by Griffith. Breeding-cage observations are never quite conclusive.

So great is the practical importance of this point, as already shown and as will be elaborated later, that the most careful experimental work should be undertaken under all sorts of circumstances and in very many different localities.

II

THE NATURAL ENEMIES OF THE TYPHOID FLY

AS with every other living creature, nature makes its own effort to limit the abundance of the fly under consideration, and the extraordinary facility for multiplication which the fly possesses is in turn the result of the instinctive effort of the organism to maintain its status in spite of the numerous enemies which confront it. The natural enemies of the house fly begin with the acme of the vertebrate series (man himself) and end with the lower forms of plant life, and we will begin our consideration of these agencies with the latter forms.

Fungous Diseases

In the autumn it is a matter of common observation that many flies in houses and on the windows become sluggish and frequently die in such positions. The sluggishness may be accounted for in a measure by the advent of cold weather, and as a matter of fact cold weather frequently drives indoors other species of flies of a more sluggish nature than the house fly. In this way the so-called cluster fly (*Pollenia rudis*), a rather sluggish species, which will be referred to in another chapter, is frequently found in houses in the autumn.

But the principal cause of the sluggishness on the part of the house fly in the autumn is the attack of fungous diseases. Sometimes they are found to be dead without any evidence of the cause of death. Later they are seen to be surrounded by a white fungus growth.

There is a group of fungi belonging to the Entomophthoreæ, many of which are parasitic upon insects. There are several genera in this group, but the only one which need be considered at present is the genus Empusa. The fungi of this group have been studied by Dr. Roland Thaxter of Harvard University, and it is from his writings that the following statements have been drawn.

The infection of insects by these fungi results from contact with a spore which, adhering to the insect, enters its body by means of a fungous thread known as a hypha. The exact method of the entrance of the hypha is not known, but it must be through the thinner membrane connecting the body segments and the leg joints, or through the breathing pores. It has been suggested that the spores may be eaten, but Thaxter thinks that this is not the usual means of introduction, since experiments that he has made contradict it, and he finds that as a rule the digestive tract during life does not seem to be penetrated by the fungus. After one of these hyphæ has entered the body of the insect it develops with some rapidity at the expense of the softer tissues. It multiplies, not by branching or by continuing to grow, but by the formation of short, thick fragments of various sizes and shapes that are

continually reproduced by budding or division until the insect is more or less completely filled with them. These fragments are called hyphal bodies. They contain a highly concentrated, fatty protoplasm and are capable of subsequent and often very extended development.

When the mass of these bodies has been completed and the death of the insect attacked has occurred, the fungus may proceed at once to the completion of its development under proper conditions of temperature and moisture, but if these conditions are absent a resting stage ensues in which the contents of each hyphal body becomes surrounded by a single wall which increases in thickness as the resting stage continues. The fungus may remain dormant in this condition for a considerable period. Doctor Thaxter has observed the hyphal bodies germinating after several weeks, and thinks that they probably retain their vitality for a much longer period, and may perhaps hibernate under certain circumstances.

When a moist atmosphere and a sufficiently high temperature come they germinate with great rapidity. With the common house fly fungus (*Empusa muscæ*) a slight change in the amount of atmospheric moisture is sufficient to bring about germination. This, according to Thaxter, is very noticeable on the seashore, where slight changes of the wind from the water or from the shore bring about a very rapid and noticeable effect upon the flies thus parasitized when watched in the ordinary atmosphere of the house. With other

species of Empusa attacking other insects, a much greater degree of moisture is necessary, and certain forms occur only in very moist situations.

In germinating, each hyphal body or resting spore sends out one or more hyphæ, which grow with great rapidity, but the manner of this germination, together with the subsequent development of the resulting hyphæ, varies considerably with different species and under different conditions. In the simplest case a single hypha thus produced may grow directly to the outer air and then produce a single conidium or set of conidia. In other cases a single hypha may branch indefinitely, each final branch bearing a conidium or conidia. This usually happens where the conditions of growth have been very favorable, and the complex may be found side by side with the more simple form.

The conidium or spore is formed by budding from one of these hyphæ, which in this case is called a conidiophore. This bud increases in size and becomes separated from the conidiophore by a cross-partition. Within the mother cell thus formed is developed a single spore. When this cell increases in size by the absorption of water, the wall of the mother cell becomes separated from that of the conidium and sometimes to such an extent that the conidium is seen floating free in the large spherical mother cell. Finally by a rupture the conidium is discharged violently into the air, often for a considerable distance. With *Empusa muscæ,* the conidia are bell-shaped or nearly spherical, with a broad base and a measurably pointed apex,

They contain usually a large oil globule and are surrounded after discharge by a mass of protoplasm.

If the conidium when discharged has come in contact with a suitable host insect, it adheres to it and sends out a hypha of germination which enters its body as just described. Secondary conidia are formed as a provision for further dissemination in case the primary spore has fallen on a substance unsuited to its proper development. With *Empusa muscæ* the secondary conidia are like the primary, or more commonly they are sub-ovoid, small, round at the apex, and formed by direct budding from the primary form. These also are discharged, but are apparently better suited to resist unfavorable conditions than the primary ones, and probably retain their power of germination much longer.

There is also another morphological character of these fungi—the formation of simple hyphæ which project out beyond the conidiophores. When they reach in the direction of the material upon which the destroyed insect stands they attach the body to it, and are then called rhizoids. When they stick out in any other direction, however, they seem to be functionless and are called cystidia or paraphyses. The hyphæ of attachment or rhizoids may be simple or variously branched, and their germination may be variously modified into an extended sucker. They do not seem to enter into soft substances, and their adhesion is apparently due to the presence of a viscous secretion. They are produced with great rapidity, appearing often

before the host is dead, and increase greatly in number with the appearance of the conidiophores.

This will suffice perhaps for a general account of the development of these curious parasitic fungi. *Empusa muscæ* Cohn., one of the most abundant of them, attacks the house fly, and also certain other large flies, such as the blow flies and many flower flies. It was first described by DeGeer in 1782, and has since been carefully studied by many observers. It is almost as universal as the house fly itself, and is the only Empusa known south of the Equator. As a rule, according to Thaxter, the species is found about houses, usually within them, and occurs in great abundance from late June until late in the autumn. It seems altogether likely that the majority of the deaths of flies in the late autumn are caused by this species. In England, according to Hewitt, it is found from about the beginning of July to the end of October, usually indoors. In Washington the epidemic ceases in December.

It is not yet known how this fungus lasts over from one year to another. Mycologists have never grown it in artificial cultures, and there is evidently much yet to be learned about many important points in its life history. Much experimental work has been done with the fungus diseases of other injurious insects, particularly with those of forms injuring cultivated crops, but no striking large-scale results of value have been obtained. It is possible that something practical can be gained from a close and prolonged study of this disease of the house fly, and it is interesting to note

that the city of London local government board on public health and medical subjects is now aiding Dr. Julius Bernstein in a detailed investigation of the life history of *Empusa muscæ* and in an attempt to cultivate it in artificial media, with the object, if possible, of employing these cultures to destroy flies on a large scale.

Two other species of Empusa are recorded by Thaxter as developing in the typhoid fly. These are *E. sphærosperma* (Fres.) Thaxter and *E. americana* Thaxter. *E. sphærosperma* is peculiar for the great diversity of its hosts, since it destroys insects of all orders except that to which the grasshoppers belong. It is a very common form and often produces very considerable epidemics among insects. It is recorded as destroying the clover weevil in great numbers on one occasion near Geneva, N. Y., by Dr. J. C. Arthur, and in 1909 produced an extraordinary epidemic in the same insect in the vicinity of Washington, D. C.

As it happens, an allied insect, probably accidentally imported from Europe, is causing great damage at the present time in the alfalfa fields in Northeastern Idaho. Prof. F. M. Webster of the Bureau of Entomology at Washington immediately conceived the idea of attempting to introduce this fungus from Washington into Idaho, in the hope that it would attack the alfalfa weevil. Owing to the dry climate out there, however, the experiment failed; the conidia would not develop, and it would seem very difficult if not impossible to produce, artificially, moisture conditions which will enable alfalfa growers to handle this disease practically.

The only record of the attack of this species on *Musca domestica* is by Brefeld. *Empusa americana* seems confined to large flies, like the house fly, the blow flies and the like. Doctor Thaxter states that it is frequently met with from June to October on the borders of woods near brooks or in shrubbery about houses. The fly is generally found fixed to the under, or rarely the upper, sides of leaves or bare twigs a few feet above the ground. It occurs in New England and North Carolina. The rhizoids or attaching hyphæ, instead of growing out in the form of numerous scattered threads, are developed in an even layer around the insect's body, forming with the conidiophores a continuous mat-like covering, which often becomes dark rust colored on exposure to the weather.

These are, so far as known, the only true botanical enemies of the house fly. Of course, breeding as it does in fermenting organic matter and in the dirtiest and filthiest locations, and frequenting such situations as it does in search of food, it carries upon its body, and within its alimentary canal for the brief period which it takes for its food to pass through, any number of spores of fungi and of bacteria, but it is probable that nearly all of these are carried accidentally by the fly and do it no harm. Many species of many genera of fungi and bacteria have been cultivated upon sterilized plates upon which flies caught haphazard have been allowed to walk and which they have been allowed to speck, but as just stated these are probably innoxious to the fly itself. From the observations of

Mr. H. T. Güssow, Dominion Botanist of Canada, quoted by Hewitt, the fungi reared in this way have numbered seven species, while the bacteria have numbered eleven species.

Protozoan Enemies of the House Fly

Certain microscopic protozoa of the group Flagellata have been found in the alimentary canals of various insects, and one species known as *Herpetomonas muscæ domesticæ* has been found in the intestine of the house fly. The genus to which it belongs is said by Calkins to be the most primitive and least changed from the free-living forms of the flagellated intestinal parasites. It is a general parasite of flies of very wide distribution. It was carefully studied by Prowazek in 1904 and by Captain W. S. Patton of the Indian Medical Service in 1908 and 1909.

Patton found that in Madras, India, about one hundred per cent. of the flies caught in the bazaar meat shops are infected with this parasite, and he made an exhaustive study of its life history which continued for more than a year. He found that it exists in three stages which he calls the preflagellate, the flagellate and the postflagellate. The first stage is usually found in the midgut, the parasites lying in masses within the peritracheal membrane. They are round or slightly oval bodies of very minute size, which multiply by simple longitudinal division or by multiple segmentation so that a large number is formed in a short time. The flagellate stage is characterized by the projection

of a single stout filament. In this stage it elongates and divides later by simple longitudinal division. In the postflagellate stage the organism shortens in length and eventually loses its filament.

Whether the presence of these intestinal parasites affects the vitality of the fly is not mentioned, nor is it understood whether they can be transmitted to any other animal.

Since the typhoid fly does not bite, it seems likely that such a transfer does not take place. It is interesting to note, however, that a parasitic flagellate of the same genus, namely, *Herpetomonas donovani,* is the causative organism of the tropical disease known as kala azar, characterized by an enlargement of the spleen, by irregularly recurrent fevers, anæmia and emaciation, usually resulting in death, and that Captain Patton has discovered that the same parasite undergoes a transformation in the intestine of a bedbug (*Cimex rotundatus*) in India, confirming a suggestion made with reasons by L. Rogers, who had previously discovered the flagellated stage of the parasite. When the blood of a kala azar patient is sucked into the alimentary canal of the bedbug the parasites are liberated by the digestive process and begin to develop from the second to the fifth day. There is no evidence that the bedbugs are infected except from human beings, and there is no scientific proof that human victims acquire the disease from the bugs.

Another flagellate genus, Crithidia, is found in the intestinal tract of certain flies, and one of them has

also been given the specific name *Muscæ domesticæ* by H. Werner.

Nematode Parasites of the Typhoid Fly

The nematodes, or thread-worms, have long been subjects of observation. They are greatly elongated, thread-like organisms, frequently of considerable size; for the most part laying eggs, but in rare cases bearing living young. The younger stages or larvæ of most of them have a different habitat from that of the adult worm. Some of them develop in damp, muddy earth, migrating finally to lead a parasitic life within some animal; some are parasitic in plants. The old time superstition that a horse-hair when left in water for a sufficient length of time becomes a living worm arises from observations upon some of the largest nematodes. Very many insects are parasitized by the worms of this group.

H. J. Carter, in Bombay, in November, 1859, while examining the head of a common house fly, noticed that two nematode worms came out of it. Later, in July, 1860, he discovered that on the average about every third fly in Bombay contained from two to twenty or more of these worms, which were chiefly to be found in the proboscis, though occasionally occurring among the soft tissues of the head and hinder part of the abdomen. He described them as bisexual, mature, and nearly all of the same size. He placed them in the genus Filaria, and described them as *Filaria muscæ* in the Annals and Magazine of Natural History, Vol. VII, pages 30-31.

Other observers have studied this parasitic worm, which is now placed in the genus Habronema. Hewitt, in England, after dissecting many hundreds of flies, found only two specimens of this parasite. He feels certain that the one found in England is the same as the one found by Carter in India.

The same species occurs in the United States and has received some attention from Dr. B. H. Ransom, of the Bureau of Animal Industry of the U. S. Department of Agriculture at Washington. Doctor Ransom has very kindly given the writer the following note, hitherto unpublished, which is sufficiently interesting to print in full:

"Referring to *Habronema muscæ,* this parasite seems to be very common in the house fly. Out of thirty-four flies examined between June 10th and July 11th, most of them caught in the laboratory of the Zoological Division, the remainder bred from horse manure obtained at the Experiment Station of the Bureau of Animal Industry, Bethesda, Md., nine were infested. The number and distribution of the parasites in these nine flies were as follows:

1. Five in the proboscis.
2. Six in the head and proboscis, one in the thorax.
3. One in the head.
4. Two in the head.
5. Five in the head.
6. Two in the head.
7. One in the head.
8. One in the abdomen.
9. Two in the thorax.

"Twenty-six dipterous larvæ (species not determined) from horse manure which were examined for the presence of nematodes were all free from infection with *H. muscæ*. Thirteen larvæ of *Musca domestica* and several pupæ were examined with negative results. These were bred from house flies confined in a dish with horse manure which had previously been boiled to destroy any fly larvæ or nematodes which might have been present. That some of the flies were infested with Habronema was determined by examining a number after oviposition had occurred. An undersized male which developed in the culture just referred to, the only adult that was obtained in this culture, was examined with negative results.

"That infection with *Habronema muscæ* is acquired during some stage prior to the imago was proved by the discovery of the parasites in a fly caught just as it was emerging from the pupa (No. 9, referred to above). Beyond this fact the observations made by me (made incidentally in the course of another investigation) have proved little as to the life history of the parasite. On several occasions I have placed the worms taken from flies in water and in horse manure, but in no case was it observed that any further development occurred. The worms invariably died within a few days. It would seem, however, that the larval stage of the parasite which is found in the fly must in some way escape from its host, reach sexual maturity either as a free living form or in another host, and produce young which find their way into other flies

during an early stage in the development of the insects. It is improbable that the worms develop to maturity in the fly, since they have been found only in the larval stage in that host. It might be noted in this connection that Carter erred in identifying certain structures as reproductive organs."

Other nematodes have been found in the typhoid fly, but it is not as yet determined that they are surely distinct from the one just mentioned.

The Mite Enemies of Musca Domestica

Many flies of different species are often noticed to have small red mites attached to their bodies. This has been found to be the case with small flies as well as with large ones—even mosquitoes have enemies of this kind. Some of these mites probably exert a deleterious effect upon their host and are true parasites, but with others the flies simply act as aeroplanes to carry the mites from one place to another. (A free ride seems to be the only object for which they have attached themselves to the fly.)

Attention was called to these mites in the first place by DeGeer in 1735. Linnæus wrote of one of them in 1758, and other writers have made mention of them and have described several species. Mr. Nathan Banks, an authority upon this group of creatures (Arachnids), has given the writer the following information:

"Latreille based a new genus and species on mites from the house fly, and he called it *Atomus parasiticum.* This is the young of one of the harvest mites of the

family Trombidiidæ, but the adult has not been reared and is still unrecognized in Europe. Riley found these harvest mites on house flies in Missouri, in some years so abundantly, he says, that scarcely a fly could be caught that was not infested with some of them clinging tenaciously at the base of the wings. Later he succeeded in rearing the adult, and described it as *Trombidium muscarum*. In recent years Oudemans has described *Trombidium muscæ* from larval mites found on house flies in Holland.

"All these forms are minute, six-legged, red mites, which cling to the body of the fly and with their thread-like mandibles suck up the juices of the host. They are nearly related to the so-called 'red-bugs,' or 'chiggers,' of the Southern United States. When ready to transform, they leave the fly and cast their skins, the mature mite being a free-living, hairy, scarlet creature about one and five-tenths mm. long. The adults are usually found in the spring and early summer, while the larvæ are usually found in the autumn on house flies and other insects.

Mites of the genus Pigmeophorus, of the family Tarsonemidæ, have also been taken on house flies. They cling to the abdomen of the fly, but it is not certain whether they feed on the insect or use it simply as a means of transportation. The hypopus, or migratorial nymphal stage of several species of Tyroglyphus, has been found on house flies. This hypopus attaches itself by means of suckers to the body of any insect that may be convenient. The mites do not feed

on the fly, but when the fly reaches a place similar to that inhabited by the mites the latter drop off, cast their skins, and start new colonies. DeGeer observed large numbers of these tiny mites on the back and neck of the house fly. Linnæus named one of them *Acarus muscarum.* Berlese has reared from stable flies what he considers as this *Acarus muscarum* of Linnæus, and finds that the adult belongs to the genus Histiostoma.

The hypopi most commonly found on the house fly are those of the common household cheese- ham- and flour-mites. All through the summer months, and in warm houses during the winter months, these creatures breed with astonishing rapidity and fecundity. The females bring forth their young alive, and these in turn reach full growth and reproduce until a cheese, once infested by a few, swarms with the crawling multitude which causes its solid mass to crumble and become mixed with excremental pellets and cast-off skins.

During the summer months the mites are soft-bodied and have comparatively feeble powers of locomotion, and, as they become numerous enough to devour the whole of a cheese with no other food at hand, it was for a long time a puzzle to know what became of them and to understand how a cheese could become infested without coming in contact with another infested cheese or without being placed in an infested room. It has been learned, however, that when necessity requires it and when the insects happen to be in the proper stage of growth, they have the power not only of almost indefinitely prolonging existence but of undergoing a

complete change of form, acquiring hard, brown, protective coverings into which all of the legs can be drawn in repose. In this hard shell, or hypopus state, it may remain for many months without food.

In the majority of cases, however, where a given cheese is completely destroyed, all of the young and old mites perish, and only those of middle age, which are ready to take on the hypopus condition, survive. These fortunate survivors, possessing their souls in patience, retire into their shells and fast and wait, and, as everything comes to him who waits, some lucky day a house fly comes that way and the little mite clings to it and is carried away to some spot where another cheese or food in some other form is at hand.

Spiders as Fly Enemies

In spite of the well-remembered poem beginning "'Will you walk into my parlor?' said the spider to the fly," it is a curious psychological fact that the writer had practically completed the writing of this chapter on the natural enemies of the house fly before he discovered that he had forgotten to say anything about spiders. That was not because he is getting old and forgetful, but because in the rooms which he has had the good fortune habitually to frequent during later years he has rarely seen a spider. Although, if given the opportunity, they would kill an unlimited number of flies, they are not permitted to build their webs and increase in localities where the flies are the greatest nuisances; that is to say, in houses, shops, and hos-

pitals. It will not be necessary, therefore, to give spiders any extended consideration here. Mr. Nathan Banks, the well-known writer on these interesting creatures, has jotted down for the writer the following brief notes on the subject:

"The most common spider in houses is *Theridium tepidariorum* Koch. It occurs throughout the civilized world. It builds an irregular web in the upper corners of rooms, and if the housewife is not too tidy, one may often see flies in its webs. *Steatoda borealis* and *Teutana triangulosa* are related spiders, occurring in this country and in Europe; their webs are commonly under or behind furniture, in darker places than those of the Theridium. They do not catch as many flies, but their webs are safer from the housekeeper's broom.

"*Agalena nævia,* a common field spider, is frequently found in houses, especially outhouses, outside kitchens, etc.; sometimes they live in these double screens; they need some crack or hole in which to retire; the web spreading fan-like from this hole, which they line with silk.

"*Salticus scenicus* is a common jumping spider about houses, usually on the outer side of houses, but often seen on windows, where one may watch with much interest their method of stalking and suddenly leaping on unsuspecting flies.

"In cellars, packing boxes, and other dark places, other spiders occur; *Tegenaria derhami* and *Amaurobius ferox* being common in the United States and in Europe.

"Several of the orb-weaving spiders are often found on porches, where their snares will intercept many flies. *Epeira sericata* nearly always occurs near or on buildings."

False Scorpions on Flies

There is a group of Arachnids, known as the false scorpions or pseudoscorpions, which are much smaller and simpler in structure than the true scorpions. They have no poison gland and no spine at the end of the body. They bear much the same relation to the true scorpions that the mites do to the true spiders. They live beneath the bark of trees, in moss, between the leaves of old books, etc. They run sidewise and backwards, and live on mites and small insects. Two or three species of the false scorpions are sometimes found clinging by their claw-like pedipalps to the legs of the house fly and other kinds of flies. It is not known why they attach themselves to these insects, but it is hardly probable that they feed on them, and it seems altogether likely that they simply attach themselves in the same way as does the hypopus of the Tyroglyphid mite, in order to be carried to some better feeding ground. Much has been written upon this subject, and many different views are held about this attachment, but there is no sound evidence on the one side or on the other. The suggestion has been made that the false scorpion seizes the legs of the flies without realizing their size, and that they remain attached until the fly dies and then they feed upon the body. Doctor

Hewitt has reviewed the habits of one of the species known as *Chernes nodosus* Schrank, which, he states, is more abundant in England in some years than in others. He quotes Godfrey (1909): "The ordinary habitat of *Chernes nodosus,* as Mr. Wallace Kew has pointed out to me, appears to be among refuse, that is, accumulations of decaying vegetation, manure heaps, frames and hotbeds in gardens. He refers to its occurrence in a manure heap in the open air at Lille, and draws my attention to its abundance in a melon frame near Hastings in 1898, where it was found by Mr. W. R. Butterfield." Doctor Hewitt very justly calls attention to the fact that it is not difficult to understand the frequent occurrence of this false scorpion on the legs of flies, in view of the facts just quoted from Mr. Godfrey, since flies frequent such rubbish heaps for the purpose of laying eggs, or he suggests that when they have recently emerged from puparia in such places and are crawling about while their wings are drying their legs are readily to be seized by the Chernes. In closing his account of this species he writes, "It is obvious that the association [between the Chernes and the fly] will result in the distribution of the pseudoscorpionid, but whether this is merely incidental and the real meaning lies in a parasitic or predaceous intention on the part of the Arachnid, as some of the observations appear to indicate, further experiments alone will show."

THE HOUSE CENTIPEDE

There is a small, rather fragile-looking centipede, known scientifically as *Scutigera forceps* Raf., which for many years has been a constant inhabitant of houses in the Southern United States, and which seems to have been gradually extending its northward range. It is now occasionally found in houses as far north as Albany, N. Y., and perhaps even farther.

It seems to be peculiarly a domestic animal; that is to say, it has accommodated itself perfectly to the conditions existing in human habitations. Its form and its sudden movements have made it an object of fear, especially to women and children. It is fond of damp localities, and is especially abundant in bathrooms, in basements, in cellars, and in ground-floor kitchens and pantries, where there is more or less dampness and warmth. It has been called the skein centipede, since when crushed its long legs look like a mass of threads. This creature, as has been shown by Marlatt (1896), seems to be a normal inhabitant of the southern tier of the United States, spreading north into Pennsylvania as early as 1849 and reaching New York and Massachusetts twenty or twenty-five years later. It is now common throughout New York and the New England States and extends westward beyond the Mississippi.

The character of its mouth parts indicates that it is predatory and carnivorous in its habits; the jaws are strong, and its food consists principally of other in-

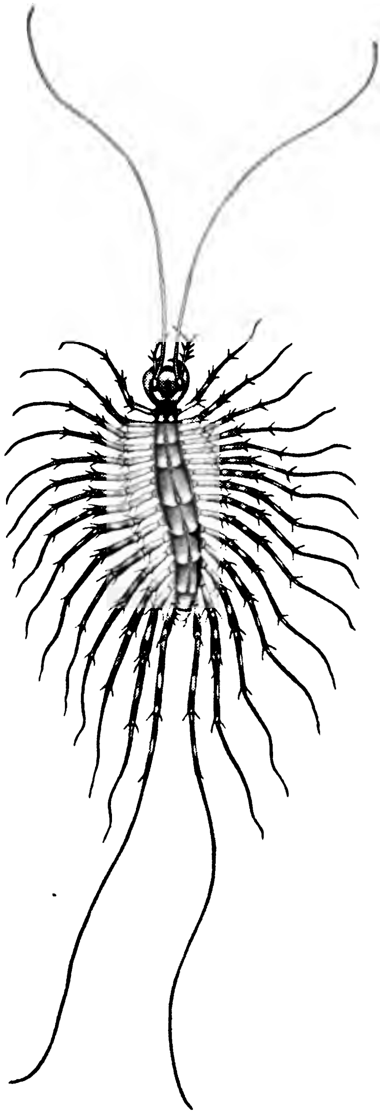

Fig. 17.—The house centipede (*Scutigera forceps*); somewhat enlarged. (After Marlatt.)

sects living in houses, such as house flies, small cockroaches, and clothes moths. Years ago the writer observed its method of catching both Croton bugs and house flies upon the wall of the kitchen of a house in which he lived in Georgetown, D. C. It feeds and is especially active at night, being seen in the daytime usually only when disturbed. On this occasion, with the late Dr. James Fletcher, the writer went to the pantry in the evening and saw a good-sized specimen of the Scutigera on the wall eating something. The light was turned as low as was consistent with fairly clear observation. The object held in its front legs was seen to be a small Croton bug. It was eaten with astonishing rapidity, but in the act of eating this specimen a house fly was observed by the centipede, close to it, resting upon the wall. It instantly jumped, apparently with all of its legs at once, and covered the fly, which was thus confined as if it had been in a hen coop. When the Croton bug was devoured, the pair of legs opposite the fly seized it and passed it to the pair of legs immediately in front, and in succession it was passed up to the front legs, by which it was held while being devoured. So it is obvious that its great number of legs are of use, not only in walking, but in the capture of its prey. The same operation was repeated several times.

The popular belief is that this little creature is very poisonous, and indeed it belongs to the poisonous group of centipedes. Very few cases are recorded, however, of its having bitten a human being, and it is question-

able whether it would attack any animal or insect larger than itself. Marlatt states that if pressed with the bare foot or hand, or if caught between sheets in beds, it will unquestionably bite in self-defense. He also shows that the few such cases on record indicate that severe swelling and pain may result from the poisonous injection. Prompt application of ammonia, however, will alleviate the symptoms.

No one knows much about the life history of this creature. Full-grown specimens are found in houses all through the year; half-grown individuals are sometimes found in the summer; the youngest ones known differ from the older ones chiefly in having fewer legs. It is interesting to note that a careful look at the hind segments of the young will show the long posterior legs folded up within and ready to be extended after the next molt.

Under present conditions of house fly abundance, it might be as well not to disturb this Scutigera when it is found in houses, but with the conditions which will shortly be brought about, we hope, it will be easy to destroy the centipedes with pyrethrum powder, even if they do not, as is likely, die of starvation.

Insect Enemies of the House Fly

Predatory enemies.—It seems rather strange that, with the very numerous predaceous insects which derive their sustenance from soft-bodied and more or less helpless species, there should not be more which gain their livelihood from the larvæ of the typhoid fly. It

is true that the larvæ of certain Carabæid beetles, and especially those of the genera Harpalus, Platynus and Agonoderus, are sometimes found frequenting manure and feeding upon young fly larvæ, and that certain rove beetles and their larvæ, of the family Staphylinidæ, are also found in the same situations, engaged in the same task. And Packard (1874) records the finding of a beetle pupa in the puparium of the house fly. But one would think that a pile of horse manure swarming with fly larvæ would attract hordes of predatory beetles and of pirate bugs and the like. Is it that house fly maggots are distasteful to these voracious creatures? Or is their perception of odors keen and are the ammoniacal odors of the manure pile repugnant? It is difficult to say. The typhoid fly belongs plainly to a most persistent type, and it feeds freely and abundantly in close proximity to many insects which we would naturally suppose to be its enemies.

But we must not forget the ants. It is true that many ants are nuisances, and in the case of the destruction of the typhoid fly by ants we have simply one nuisance multiplying at the expense of another, but Forel and Wheeler admit that as a group ants are beneficial and that many species deserve our protection. Capt. P. L. Jones of the U. S. Army Medical Corps (quoted by Garrison, U. S. Naval Med. Bull., Oct., 1910, p. 551) made certain experiments in the Philippines to determine whether the scarcity of flies in those islands was due to some epidemic disease. In the course of the experiments it was found impossible to raise flies

unless the eggs and larvæ (in manure) were protected from ants, as the latter invariably carried off both eggs and larvæ and even pupæ.

In the work against the cotton boll weevil carried on in the Southern United States by the experts of the Bureau of Entomology of the U. S. Department of Agriculture, it was found that the "fire ant" of the Southern cotton fields (*Solenopsis gemminata,* var. *diabola*) is an important enemy of the weevil, and strong efforts were made to multiply the ants. It was soon found that they were strongly attracted to horse manure and undoubtedly destroyed all its other insect inhabitants. Mr. W. D. Pierce of the Bureau informs the writer that the little black ant *Monomorium minimum* also frequents horse manure heaps in Texas, and he also says that several species of the ant genus *Pheidole* have this habit.

Moreover, that famous pest in Louisiana and parts of California, known as the "Argentine ant" (*Iridomyrmex humulis*) nests readily in horse manure, and its active, pugnacious and predatory habits undoubtedly induce it to prey upon the maggots found there.

Mr. Pierce's ant suggestion was of sufficient interest to follow up, and therefore the writer has corresponded with Prof. Wilmon Newell, of College Station, Texas; Prof. J. B. Garrett of the State University of Louisiana at Baton Rouge; and Mr. T. C. Barber, in charge of the Audubon Park laboratory of the U. S. Bureau of Entomology at New Orleans—all of them men who have had intimate acquaintance with the Argentine ant,

and who have made special studies of its habits. The reply from each was the same in its general tone.

Professor Newell never found the Argentine ant nesting in pure horse manure, but has found them in manure that contained a large amount of straw or hay. A certain public dumping ground carrying much manure was heavily infested with the ants, but house flies bred from it in such enormous numbers that the health officer was called in. The observer found colonies of ants on the ground and also an abundance of fly larvæ. His experience has been that house flies are not noticeably reduced in places where the Argentine ant swarms.

Professor Garrett writes that the mess hall in which about 300 of the students take their meals is in a locality where the ants are very abundant, and yet the house flies are apparently as numerous as ever. He thinks that the ants do destroy quite a number of larvæ in manure, but that they do not use them as an article of food to a sufficient extent to cause an appreciable decrease. Mr. Barber is of the same opinion.

Mr. F. C. Pratt, an agent of the Bureau of Entomology, located at Sabinal, Texas, made an especial study of fly larvæ at Dallas on one occasion. He found that the fire ant, on one occasion when he was experimenting with cow manure in order to raise parasites of the horn fly, took complete possession of his rearing cages and their contents. In his opinion, they feed upon all fly larvæ.

Aside from ants, there are other predatory insect enemies of flies not yet mentioned. Wasps catch house

flies, sometimes in considerable numbers. It is not an uncommon sight to see any one of several different species of wasps flying about houses, capturing flies both on the wall and on the wing. The robber flies of the family Asilidæ also catch house flies, on porches sometimes. On the whole, however, the predatory insect enemies of the house fly are negligible, so far as the beneficial result of their work is concerned.

Parasitic Enemies

To a certain extent the same may be said of the parasitic enemies of this species, but these are perhaps more numerous than the predatory insect enemies, and several of them are accustomed to frequent excreta in the search of larvæ in which to deposit their eggs. This is especially true of cow dung, and many minute hymenopterous parasites may be found frequenting droppings in the pasture in order to lay their eggs in some one of the many species of maggots which are to be found there in a very short time.

These very minute, active, four-winged parasites belong either to the subfamily Figitinæ of the gall-fly family Cynipidæ or to the superfamily of true parasites known as Chalcidoidea.

In the gall-fly family, Cynipidæ, most of the species of which produce galls upon living plants and very numerously upon the oak, there is one subfamily of minute forms, the Figitinæ, parasitic upon other insects and for the most part upon dipterous maggots. Those frequenting cow dung will lay their eggs in apparently

almost any one of the many species of dipterous larvæ found there, and have been reared from the larvæ of the horn fly, from several species of true dung-flies (family Scatophagidæ), and from others. Two species, however, are reared from the maggots of the typhoid fly. These are *Figites anthomyiarum,* reared from the house fly in Germany by Reinhard, and *Figites scutellaris,* also a European species. If careful rearing experiments were carried out continuously in this country with house fly larvæ, it is probable that other species of this group would be reared. Prof. T. D. A. Cockerell, for example, caught one of them—*Eucoila impatiens* Say—on horse dung at Las Cruces, N. Mex., in 1894, and suspected its parasitism on house fly larvæ (Insect Life, VII, 209). Many similar observations can doubtless be made very easily.

The Chalcidoid parasites of *Musca domestica* are more numerous. In the family Pteromalidæ there is a genus, Spalangia, which seems practically confined to dipterous larvæ. One species, *Spalangia niger,* was found by the German author Bouché to lay its eggs in the pupæ of the house fly and to issue in April and May. The larvæ of the Spalangia are spindle-formed and white, almost translucent, and are to be found in the autumn in the puparia of the house fly, where they destroy the true pupæ.

Several species belonging to this same genus are to be found in the United States, and one of them at least has similar habits. Mr. H. L. Sanford, of the Bureau of Entomology at Washington, in opening a series of

puparia of *Musca domestica* in January, 1911, in order to ascertain what proportion of the pupæ were living, was surprised when a fully formed and active adult black Spalangia crawled immediately from the opening made by his dissecting needle. This will be described by Girault as *Spalangia muscæ*. A certain proportion of the house fly puparia are affected by this parasite in precisely the same way as are the puparia in Europe by *Spalangia niger* as described by Bouché. Mr. Sanford's observation shows that the adults may be fully formed and ready to emerge at a very early date.

Another European Pteromalid parasite, namely, *Stenomalus muscarum*, is recorded as being a parasite of the house fly pupa.

Much attention has been given to the Chalcidoid parasites of the typhoid fly by A. A. Girault and G. E. Sanders, of the University of Illinois. In their first paper (*Psyche*, December, 1909, pp. 119-132) they described an interesting form under the name *Nasonia brevicornis* from a series of 640 specimens, nearly all reared from puparia of various flies in the Office of the State Entomologist of Illinois at Urbana during 1908. They came from various decomposing materials, from which several species of flies were reared, but a number undoubtedly came from *Musca domestica*.

It is a minute, dark, metallic, brassy-green fly with clear wings and rather stolid and serious temperament. Girault and Sanders state that it heeds external influences very slightly, and quietly and persistently gives its whole attention to reproduction. They found that

both sexes crawled rapidly. The female is able to fly; but the favorite mode of locomotion appears to be crawling. The wings of the male appear to be non-functional. Actual experimentation with fifty maggots and ten puparia of the house fly showed that the parasites laid their eggs in the puparia and developed rapidly. The maggots and puparia were placed in a breeding jar on September 9th, and on September 26th six males and ten females of the parasites issued from the puparia. On September 12th, eight female parasites were confined separately in small gelatine capsules, each with a healthy puparium of the house fly. The parasites appeared to lay their eggs in several cases, but none issued afterwards and about half of the flies came out.

Most careful observations were made by the authors on the egg-laying process of this parasite. The female was observed to walk carefully over a two-days' old puparium, examining the entire surface. After a point was selected, the ovipositor was inserted with some difficulty, the operation requiring one minute and a half. The hole was then enlarged, and the ovipositor was again pushed in for its entire length and remained for forty-five seconds, during which time apparently an egg was deposited. After the ovipositor was withdrawn the parasite examined the puncture with its antennæ and mandibles.

The parasite apparently attacks only the puparium, and that only after it has been formed for about twenty-four hours, and a number of them issue from the same

puparium. Observations were carried on through succeeding months and the duration of the life cycle was carefully studied (*Psyche,* February, 1910). The life cycle is longer in the spring and shorter in summer, the average life cycle being twenty-two and one-half days with usual temperature. They found that one female was able to parasitize twenty-two puparia and another one seventeen. The authors suspect that the phenomenon of polyembryony, that is to say, the development of a number of adult individuals from a single egg, takes place with this species. Counts of several thousand reared specimens of the parasite indicated that fifty-eight and nineteen-hundredths per cent. of them were female and forty-one and eighty-one-hundredths per cent. were males. They found that the adult parasites issue from the host puparium through from one to three circular holes of various positions, several issuing from each hole. As to the abundance of the parasite, the authors indicate that during September and October, 1908, they reared 8,000 or more specimens, and these were reared quite accidentally, that is to say, without conscious effort on their part to increase the number. The local abundance of the parasite was indicated by the fact that in a portion of a given experiment the percentage of parasitism was as high as ninety per cent. This percentage of mortality on the part of the house fly, however, was by no means general, and the parasite had apparently concentrated its attack on certain spots. The authors made an unsuccessful attempt to propagate the species artificially

by scattering 1,000 specimens of mixed sexes over a garbage heap on September 23d. This, however, was too late in the season, and weekly collections of fly puparia thereafter gave no result.

The authors found that this parasite hibernates as a full-grown larva in the puparia of the flies, transforming to pupa early in the spring and emerging shortly afterwards. As examples of intensive and careful study of a given species, the papers on this form by the authors mentioned are excellent.

The same authors have made a careful study of another house fly parasite of this group, known as *Pachycrepoideus dubius*. This species was reared in company with the preceding species, and the experiments of the writers indicated that it is a true primary parasite of the house fly. They were unable to make any observations on the biology of the species, except to notice that the adults in three cases emerged from the fly puparium through a single hole with jagged edges.

Still another parasite of this group, studied by Girault and Sanders, and described in *Psyche* for August, 1910, is *Muscidifurax raptor*. This is another small, clear-winged species, black in color, which was reared in some numbers from puparia of the typhoid fly at Urbana and Champaign, Illinois. It also breeds in the puparia of other flies, is solitary in its habits, and more sensitive than the Nasonia which the experimenters have described so fully. They state that the biological history of the species can be learned with ease in the laboratory, as the females are not at all averse

to ovipositing in confinement; they are, however, seemingly not as prolific or as generally parasitic as Nasonia.

The writers did not obtain certain data concerning the entire seasonal history of this parasite, but they think that it confines itself principally to the puparium stage of the house fly, hibernating in the puparium as a larva and pupating itself and emerging early in the spring as an adult four-winged parasite. The first specimens found by them emerged the first week in September, and from that time on until frost it was comparatively abundant. It was reared from puparia collected on September 23d and again from some collected on October 21st, emerging from these November 6th. Hibernation probably commenced about October 21st.

Examination of the house fly pupæ, after the parasites have emerged, indicates that the larva of the parasite feeds externally on the pupa of the fly, sucking its juices. The attachment is to any portion of the body of the pupa. Opening a puparium from which the adult parasite had emerged revealed the blackened and shrunken remains of the fly pupa lying in its natural position along the floor of the pupal shell.

The meconium, or excrement passed by the parasite larva when about to change to pupa, is distinctive —dark in color and round-angled, looking like a small, solid, black, round bit, resembling somewhat a coarse grain of powder but not as irregular or angular. It differs from the meconium of the other parasites of the house fly studied by the authors mentioned. The adult

parasite issues through a single rounded hole cut in the pupal skin of the fly. The two sexes issue almost simultaneously, the males a little before the females. Each female appears to lay thirty to forty eggs. Out of 288 specimens reared, eighty-five were males and 203 females, and the average duration of the life cycle was nineteen days and seventeen hours.

Girault will continue his intensive study of fly parasites and will undoubtedly learn many new and important facts. Additional species have already been reared by him and await systematic study.

Vertebrate House Fly Enemies

The common garden toad, the great collector of insects, will catch a house fly whenever it is able to do so. It is, in fact, a pleasing occupation to feed house flies to a good-sized toad, in order to ascertain his capacity. But these animals are not inhabitants of houses.

Some of the lizards that run about houses in tropical regions feed upon flies, and the occupancy of houses by these creatures is not objected to by natives, for this as well as for other reasons.

Birds are not effective as house fly enemies. Of the wild birds, comparatively few feed upon them at all, although there are many insectivorous species which would do so if they were allowed to nest in houses. As a matter of fact, however, in all the records of the Bureau of Biological Survey of the U. S. Department of Agriculture, which represent the examination of the contents of the stomachs of many thousands of birds,

there are only two records of the finding of house flies, and one of these is somewhat doubtful.

One of their records shows the finding of thirty-three larvæ in the stomach of a horned lark, but it is quite possible that these larvæ were not those of *Musca domestica.* The other record shows the finding of a single adult house fly in the stomach of a white-eyed vireo. The writer has watched the house wren feeding its young hour after hour, and has noticed that the insects brought to the nest were for the most part small caterpillars, although there were plenty of flies on the porch where the nest was built.

The great group of insectivorous birds known as the fly-catchers as a matter of fact do not prefer the flies. As the writer has been told by Prof. F. E. L. Beal, an authority on the subject, they feed by preference upon winged hymenopterous insects, which constitute the bulk of their food.

W. D. Doan in Bulletin 3 of the West Virginia Experiment Station records finding house flies in the stomachs of the cedar bird, the wood pewee, and the palm warbler.

Domestic poultry, however, when given the opportunity, will feed with some avidity upon house fly larvæ. Hens given the run of a barnyard destroy very many larvæ in scraping about the edge of the manure pile, and more than one letter has been received from persons who, admitting flocks of poultry to the barnyard for the first time, have discovered an appreciable reduction in the number of adult flies visiting the house.

Fly-Catching Rats

A number of mammalia in captivity have been seen to capture flies, but as a rule they seem to do this very much as the idle house dog will snap at the fly circling about his head. A most interesting observation, however, has been made by Prof. B. W. Evermann, of the Bureau of Fisheries in Washington. At a meeting of the Biological Society of Washington, held January 7th, he gave an account of a visit in early July of 1910, at Kokomo, Indiana. He stopped at a hotel and was sitting on the piazza on the evening of his arrival. Back of him was a window which opened into a storeroom for provisions, etc. Inside the window was a lace curtain which hung closely, and uniformly covered the entire window. Happening to look at the window quite by accident, Professor Evermann saw a brown rat run back and forth on the window-sill inside. It seems that a large number of flies had accumulated between the curtain and the window, probably attracted by the light from outside, and the rat was engaged in catching these flies.

In Professor Evermann's words, "It was very expert. It would move back and forth the full length of the window-sill, catching such flies as it could reach. It would frequently stand upon its hind legs to its full length with its fore paws and body resting against the glass and move backward and forward across the window. It ordinarily caught the flies with its paws, by raking the fly with one paw over against the other or

bringing the two paws together on a fly and then feeding it into its mouth."

The observer watched it for some little time and must have seen it catch more than one hundred flies. Next morning the same performance was repeated, and a large number of flies were captured. Moreover, a second rat appeared during the time the observer was watching the first one, and its methods were the same. Inquiry from the clerk at the hotel indicated that the people of the hotel had noticed the rats engaged in this occupation and had refrained from disturbing them.

Mr. W. L. McAtee, recently, in looking over an old file of *The Rod and the Gun* found the following item in the number of September 25, 1875. It is quite believable in view of Doctor Evermann's personal observations:

"Mr. C. B. Odell, at his hotel on Front Street, is the happy owner of a fly exterminator, which, for thorough work, is unsurpassed by anything we have ever seen. In one of the windows facing Front Street, where samples of his wares are occasionally shown, a rat began several weeks since to make sly visits, and secured a good meal as often as he came by catching the many flies which are on the panes of glass. He grew very expert at it, and though at first quite shy, soon became emboldened when he found he was not disturbed in his foraging expeditions, and would pursue his business not in the least intimidated by spectators, who were only separated from him by a pane of glass. He obtained entrance to this window by

gnawing a hole through the wooden base, coming from below. For weeks he has pursued his fly-hunting business undisturbed.

"On Sunday one of the waiters discovered him in the act of introducing a friend or member of his family to his foraging ground. The newcomer was very shy, and only put his head through, while the old habitué tried to coax him in the window. He would catch a fly, gravely hand it to his friend, who would as gravely eat it, and look for more. By degrees he lost a little of his fear, walked out, and soon became an expert in the new business. Either one or both may be seen almost any day by any one who may be patient enough to wait for their appearance a short time. It is certainly a very novel sight, and well worth a few minutes' time to see.—*Newburgh Telegraph.*"

Mr. Nat. C. Dearborn, of the Biological Survey of the U. S. Department of Agriculture, states that he has frequently seen evidence of the destruction of adult flies by mice on window-sills, the work having been done at night.

III

THE CARRIAGE OF DISEASE BY FLIES

IT would probably be impossible to trace the first suggestion of the carriage of disease by flies. They have been conspicuously connected with accounts of epidemics of one kind or another for hundreds of years, and before discussing some of the specific diseases which they are thought to carry some attention may be given to some of these early suggestions. It should be pointed out before taking up this subject, however, that the house fly is simply a carrier of disease germs, and that it differs in its relation to disease from the malarial mosquitoes, which are the necessary secondary hosts of the causative organisms of malaria, in that only in mosquitoes of the genus Anopheles can the germs complete their life round and develop sexual forms.

In this they differ also from the yellow fever mosquito (*Aëdes calopus*), since, although the causative organism of yellow fever has not yet been discovered, close analogy shows that it must be a protozoan dependent for its full development upon a lodgment in the stomach of the mosquito in question. It differs in the same way from the bedbug, which has more recently been seen to be probably the necessary secondary host of the causative organism of kala azar. The house fly simply carries the germs of disease, either on its

legs or in its alimentary canal, just as these germs could be carried in any other way—by water, by shell-fish, by unwashed and uncooked vegetables grown in land dressed with night-soil, on dust particles, or by personal contact.

Most of the writers who have collected data on this subject refer to the statement by Sydenham, who is said to have lived between 1624 and 1689, to the effect that if house flies are abundant in the summer the autumn will be unhealthy, and very many people hold that view; but Sydenham was by no means the first to believe that the house fly is insanitary. There are many references to this insect in the Hebrew Scriptures, and the sanitary regulations of the camps of the children of Israel in their march through the wilderness refer to flies in terms which indicate that the authors of the regulations were almost as well posted on the subject of the danger of flies as the Japanese surgeons in the recent Japanese-Russian War. I have often wondered whether the twenty-fourth verse of the eighth chapter of Exodus, "and there came a grievous swarm of flies into the house of Pharaoh, and into his servants' houses, and into all the land of Egypt: the land was corrupted by reason of the swarm of flies," did not mean that the flies corrupted the land, and whether there is not something very significant in the statement that among the plagues that followed were the murrain of cattle and the death of all the first-born of Egypt.

Several of the great surgeons of the seventeenth and

eighteenth centuries have referred to this possibility, and our own Leidy, in 1871, said that he believed that house flies were responsible for the spread of hospital gangrene during the Civil War. In that same year (1871) Lord Avebury (then Sir John Lubbock), in an article in the *London Lancet,* mentioned the fact that flies alight on decomposing matter and carry secretions with them. He uses this significant sentence: "Far from looking upon them as dipterous angels dancing attendance on Hygeia, regard them rather in the light of winged sponges spreading hither and thither to carry out the foul behests of Contagion."

Exact Experiments

There was, for a long time, no experimental proof of such carriage. There have been outbreaks of disease and single cases of disease where the carriage of the causative organism by house flies seemed to be the best explanation. Actual experimental proof satisfactory to the laboratory worker, however, has been of recent acquirement, and it will be well before entering upon the subject of specific diseases to mention some of this work.

One of the latest and one of the most careful series of laboratory observations has been made by Doctor Graham-Smith (1910). His experiments covered a wide range and seem to have been carried out with the utmost pains. The most satisfactory method of conveying his results is to give his conclusions in his own words:

"Infection experiments show that non-spore-bearing

pathogenic bacteria do not usually survive more than a few hours (five to eighteen) on the legs and wings. Nevertheless, flies allowed to walk over sterile agar plates may cause infection for several days. This seems to be due to the fact that they frequently attempt to suck the surface, and in so doing infect it with fluid regurgitated from the crop. Within the crop non-spore-bearing bacteria frequently survive for several days, and they usually survive even longer in the intestine. No evidence of multiplication in either of these situations has been obtained. The feces deposited by such flies often contain the organisms in considerable numbers for at least two days, and are frequently infective for much longer periods. Anthrax spores survived for many days on the exterior and in the alimentary canal.

"Experiments with *B. prodigiosus* show that flies may infect sugar forty-eight hours after feeding on infected material, and that clean flies may infect themselves by feeding on the recent deposits of infected flies. In the few experiments which were tried, milk and meat were not infected. Flies fed on anthrax spores did, however, infect the syrup which was given to them as food.

"In the experiments which have been described, very gross infection was produced in most cases by emulsions of pure cultures. It is improbable, however, that under natural conditions flies would often have the opportunity of feeding on materials which contain pathogenic organisms practically in pure culture. The ef-

fects of contaminating with non-pathogenic and putrefactive bacteria have as yet not been studied, and the effects of season, temperature, atmospheric conditions, different diets, irregular and scanty feeding, and other disturbing factors have not received sufficient attention.

"Consequently it would be premature to conclude that the experiments and observations described in this paper do more than indicate that, under exceptionally favorable conditions, certain bacteria can be recovered from the contents of the alimentary canal and fecal deposits of infected flies for several days after infection; and that these flies are capable of infecting certain materials on which they feed for several days. The experiments with tubercular sputum and anthracic blood alone afford evidence as to the duration of life in the contents of the alimentary canal of pathogenic bacteria taken up under natural conditions.

"That flies sometimes do become grossly infected under natural conditions is shown by the fact that in a few instances pathogenic bacteria have been isolated from naturally infected flies. Simmons (1892) isolated cholera vibrios from flies which were captured in a post-mortem room in which the bodies of persons dead of cholera were lying. Tsuzuki (1904) was able to cultivate the same organism from flies captured in a cholera house, and Tizzoni and Cattani (1886) obtained cultures from flies caught in cholera wards. Hamilton (11. 1903) and Ficker (1902) isolated *B. typhosus* from flies caught in houses in which persons were lying ill of typhoid fever, and Faichnie (1909)

obtained *B. typhosus* from a number of flies caught in various places where typhoid fever prevailed. He further showed that *B. typhosus* or *B. paratyphosus* (A) could be cultivated for several days from the intestines of perfect insects which emerged from larvæ fed on feces containing these organisms.

"Several observers [Celli (1888), Hayward (1904), Lord (1904) and Buchanan (1907)] have shown that the feces of flies which have fed on tubercular sputa contain virulent tubercle bacilli. Buchanan (1907) demonstrated that flies which had walked over naturally infected anthracic meat were capable of infecting agar plates. Yersin (1894) in Hong-Kong observed many dead flies lying about in his laboratory where he made autopsies on plague animals. He demonstrated by inoculation into animals that a dead fly contained virulent plague bacilli.

"Finally the experiments of Macrae (1894) at the Gaja jail show that exposed milk may become infected by the agency of flies.

"Even these observations only prove that cultures of pathogenic organisms may occasionally be obtained from naturally infected flies, and they do not afford conclusive evidence that such flies are a frequent source of disease in man by infecting food materials. Though many of the observations cited by Nuttall and Jepson seem to indicate that flies have frequently acted as carriers of disease, it has only once (Macrae) been demonstrated that food has actually been grossly contaminated by them."

Early laboratory experimental work in the laboratory was carried on in this country by Dr. Jocelyn Manning (1902) of Eau Claire, Wis., who succeeded in making pure cultures from infected flies of the following bacteria: *Bacillus pyocyaneus, Staphyllococcus pyogenes aureus, Bacillus typhi abdominalis and B. coli communis.*

The care with which Doctor Graham-Smith summarizes the results of his experiments and the similar observations of previous workers, in order to preserve an exactly judicial and thoroughly scientific frame of mind, is worthy of all praise, but the accumulation of evidence which has been gathered and which will be displayed in our consideration of the different diseases is so overwhelming, both from the standpoint of exact observation and of sound inference, that surely every possible effort to do away with *Musca domestica* is amply justified on the disease-bearing ground.

Other laboratory observations have been made by trained bacteriologists and mycologists in the direction of the carriage of micro-organisms by flies. One interesting series, to which the writer has referred elsewhere, was published by W. N. Esten and C. J. Mason (1908). The following table and the two subsequent paragraphs are quoted from their bulletin:

Table of Sources of Bacteria from Flies.

Date	Source	Total number	Total acid bacteria	Rapid liquefying bacteria	Slow liquefying bacteria	*Bacterium lactis acidi.* Group A Class 1	*Coli-ærogenes.* Group A Class 2
1907 July 27	(*a*) 1 fly, bacteriological laboratory	3,150	250	600	100	....	....
July 27	(*b*) 1 fly, bacteriological laboratory	550	100	0	0	....	....
Aug. 6	(*c*) 19 cow-stable flies	7,980,000	220,000	0	20,000	....	....
	Average per fly	420,000	11,600	0	1,000	....	....
Aug. 14	(*d*) 94 swill-barrel flies	155,000,000	8,950,000	0	0	4,320,000	4,630,000
	Average per fly	1,660,000	95,300	0	0	46,000	49,300
Aug. 14	(*e*) 144 pigpen flies	133,000,000	2,110,000	100,000	266,000	933,000	1,176,000
	Average per fly	923,000	18,700	700	1,150	6,500	12,200
Sept. 4	(*f*) 18 swill-barrel flies	118,800,000	40,480,000	0	14,500,000	10,480,000	30,000,000
	Average per fly	6,600,000	2,182,000	0	804,000	582,000	1,600,000
Sept. 21	(*g*) 30 dwelling-house flies	1,425,000	125,000	0	12,500	....	....
	Average per fly	47,580	4,167	0	417	....	....
Sept. 21	(*h*) 26 dwelling-house flies	22,880,000	22,596,000	120,000	34,000	....	....
	Average per fly	880,000	869,000	4,600	1,300	....	....
Sept. 27	(*i*) 110 dwelling-house flies	35,500,000	13,670,000	8,840,000	125,000	....	....
	Average per fly	322,700	124,200	80,300	1,100	....	....
Aug. 20	(*j*) 1 large bluebottle blow-fly	308,700	(*a*)	....	....	....	....
	Total average of 414 flies	1,222,570	367,300	7,830	73,500	....	....
	Average per cent. of 414 flies	....	30	6	6	....	....
	Average per fly of 256 flies, experiments (*d*), (*e*), and (*f*)	3,061,000	765,000	230	268,700	211,500	553,800
	Average per cent. of 256 flies, experiments (*d*), (*e*), and (*f*)	....	25	....	8	7	18

a 2,200 mold spores.

"From the above table the bacterial population of 414 flies is pretty well represented. The domestic fly is passing from a disgusting nuisance and troublesome pest to a reputation of being a dangerous enemy to human health. A species of mosquito has been demonstrated to be the cause of the spread of malaria. Another kind of mosquito is the cause of yellow fever, and now the house fly is considered an agency in the distribution of typhoid fever, summer complaint, cholera infantum, etc.

"The numbers of bacteria on a single fly may range all the way from 550 to 6,600,000. Early in the fly season the numbers of bacteria on flies are comparatively small, while later the numbers are comparatively very large. The place where flies live also determines largely the numbers that they carry. The average for the 414 flies was about 1,250,000 bacteria on each. It hardly seems possible for so small a bit of life to carry so large a number of organisms. The method of the experiment was to catch the flies from the several sources by means of a sterile fly net, introduce them into a sterile bottle, and pour into the bottle a known quantity of sterilized water, then shake the bottle to wash the bacteria from their bodies, to stimulate the number of organisms that would come from a fly falling into a lot of milk.

"In experiments 'd,' 'e,' and 'f' the bacteria were analyzed into four groups. The objectionable class, *coli-ærogenes* type, was two and one-half times as abundant as the favorable acid type. If these flies

Fig. 18.—Colonies of bacteria on a sterilized plate, arising from fly tracks. (From photograph by William Lyman Underwood.)

stayed in the pig-pen vicinity, there would be less objection to the flies and the kinds of organisms they carry, but the fly is a migratory insect and it visits everything 'under the sun.' It is almost impossible to keep it out of our kitchens, dining-rooms, cow stables, and milk rooms. The only remedy for this rather serious condition of things is, remove the pig-pen as far as possible from the dairy and dwelling house. Extreme care should be taken in keeping flies out of the cow stables, milk rooms and dwellings. Flies walking over our food are the cause of one of the worst contaminations that could occur from the standpoint of cleanliness and the danger of distributing disease germs."

A great deal of work of this general nature in regard to the carriage of micro-organisms by flies without specific reference as to the character of the organisms has been done and the results have been published here and there. The illustration shown at Fig. 18 is an early one made from a photograph taken by William Lyman Underwood of a gelatin plate over which a fly, captured by chance in a room, was allowed to walk. On each spot which the fly's feet touched there grew a colony of bacteria.

Cobb (1906) studied the spores of a sugar cane fungus left by the feet of a fly which had been feeding upon the fungus on the sides of a glass vessel. The spores from five of the tracks on the glass were calculated and the number per track was found to be 860,000. A second calculation gave 700,000 per foot-

print. Germination experiments showed that spores carried about in this way, if deposited in suitable locations, will germinate, and therefore the fungus may sometimes be spread in this way.

Other work of this kind, but devoted to specific disease germs, will be mentioned under the different diseases in the following pages. But in order perhaps to remove at once the impression which may be left by the cautious words of Doctor Graham-Smith, we may read the conclusions of Professor Nuttall and Mr. Jepson, of Cambridge University, England (1909), both investigators of the highest type, after their critical examination of the accounts of experiments made in this direction:

"Although there were some who at a very early date looked upon the common house fly with suspicion, it is only of recent years that 'flies' have come to be regarded as a serious factor in the spread of infective diseases.

"The evidence we have sifted and ordered in these pages is obviously very unequal in value, the most important relating to *cholera and typhoid fever*—in both cases the evidence incriminating house flies, of which *Musca domestica* may be regarded as the type, appears to be quite conclusive, and these agents will have to henceforth receive the serious attention they demand at the hands of sanitary authorities. From a practical point of view, it scarcely appears necessary to charge the house fly with more misdoings, bacteriological tests having shown that they are capable of taking up a number of different pathogenic germs and of transport-

ing them from one place to another. We regard it as certain that they convey cholera and typhoid fever, and we look forward with confidence to the complete demonstration that they convey the causative agents of infantile diarrhea and of dysentery, always remembering that there are other vehicles, water, milk, etc., by which these diseases may be communicated.

"It should be remembered that a fly may cause *relatively gross infection* of any food upon which it alights after having fed upon infective substances, be they typhoid, cholera, or diarrhea stools. Not only is its exterior contaminated, but its intestine is charged with infective material in concentrated form which may be discharged undigested upon fresh food which it seeks. Consequently, the excrement voided by a single fly may contain a greater quantity of the infective agents than, for instance, a sample of infected water. In potential possibilities the droppings of one fly may, in certain circumstances, weigh in the balance as against buckets of water or of milk!"

Surely no more authoritative or complete statement than this could be made by scientific men.

The whole literature of the subject of the transfer of disease by insects and like creatures was first comprehensively studied and collected by Dr. George H. F. Nuttall and published in 1900 in an admirable and extended paper in the Johns Hopkins Hospital Reports, entitled "On the Role of Insects, Arachnids and Myriapods, as Carriers in the Spread of Bacterial and Parasitic Diseases of Man and Animals. A Critical and

Historical Study." This paper has been of the greatest use to physicians and to naturalists, and few general articles on this subject have been written in the last ten years without the freest use of the data collected by Doctor Nuttall. In many cases writers have gone to original sources, but it is safe to say that for the most part they have learned of these original sources through Doctor Nuttall's bibliography. The writer, among others, in the numerous papers he has published on this general subject during the years since 1900, has had constant occasion to refer to this paper, and gladly expresses his obligations to its author.

More recently (1909), Doctor Nuttall (now of Cambridge University, England) in collaboration with Mr. Jepson, of Cambridge, has published a series of abstracts of literature and a bibliography relating solely to the carriage of disease by the house fly and allied non-biting flies, which has been freely used in this book and will be later referred to simply by references to Nuttall and Jepson.

Typhoid or Enteric Fever

Typhoid fever is a disease which has been differentiated from other fevers and especially from typhus within the last eighty years. It is a disease of civilization, or rather, as Doctor Sedgwick has beautifully expressed it, "a disease of *defective* civilization." It depends upon defective sanitation, and surely, as Sedgwick says, defective sanitation means defective civilization.

The true cause of the disease was not known until 1880, when it was discovered by Eberth, and it was not long before it was isolated and studied in pure culture. Technically this organism is known as *Bacillus typhosus*. It is isolated from persons who are sick with typhoid fever or who have been sick from it, and only from such persons. The disease which it causes is an intestinal disease, and through the multiplication of the bacilli in the body, and with a poisonous substance which it produces, conditions are caused which give rise to the characteristic symptoms of the disease.

Ulcerations of the intestines and enlargements of the spleen and mesenteric glands follow; and the bacilli frequently invade other portions of the body, such as the kidney, the liver, spinal column, the lungs, and they have even been found in the brain. They are given off from the body in the excrement and in the urine. The characteristic symptoms of the fever are an increasing temperature which fluctuates rather regularly, and rose rash over the abdomen, diarrhea or constipation, distention of the intestines, emaciation, and sometimes intestinal hemorrhages and delirium. The average period is four or five weeks, and this is followed by a long period of convalescence. Relapses are frequent and are dangerous and may cause death. Fatal cases before a relapse usually terminate during the fourth or fifth week.

Typhoid is thus a parasitic disease, and its onset depends upon the introduction into the system of the typhoid bacillus. Its presence in the human body is

brought about by eating or drinking something carrying the bacilli. Water, milk, oysters, raw vegetables may and do carry them. They may be carried to food in other ways: by contact; by dust; and by certain household insects, such as cockroaches, household ants, and undoubtedly frequently by the typhoid fly, the most numerous of all household insects, and the one which breeds in substances which may be normally swarming with typhoid bacilli.

Suspicions of the Carriage of Typhoid by Flies

Probably the first American to point out the probable transference of typhoid germs from box privies to food supplies by the agency of flies was Dr. George M. Kober, of Washington, D. C. In "Report on the Prevalence of Typhoid Fever in the District of Columbia," published in 1895, under the caption of "Channels of Invasion and Mode of Dissemination," Doctor Kober wrote:

"The agency of flies and other insects in carrying the germs from box privies and other receptacles for typhoid stools to the food supply cannot be ignored." On the following page he gave an account of certain cases on the Ivy City and Bladensburg Road, in the course of which he used the following words, "There is abundant evidence of unlawful surface pollution, * * * and as the germs find a suitable soil in such surroundings, it is possible that the flies which abound wherever surface pollution exists may carry the germs into the houses and contaminate the food. * * *

There was nothing in common in the milk supply of the different houses, and as there was no well liable to contamination from the first source, it is not improbable that the infection was conveyed in the manner indicated."

Writing of nine cases occurring in a certain locality in Washington, he says, "There was nothing in common in the milk supply, and the fact that the cases occurred at considerable intervals indicates with more or less certainty that the first case was a focus of infection; but how the germs were carried, unless by flies, or through the air, is a matter impossible to determine." Later, in writing of methods for the disposal of human excreta, he says, "These boxes, even if there are no wells, are still a source of danger in so far as they favor the transmission of germs by means of infected flies." In his conclusion, he writes, "A large percentage of the cases occurred in houses supplied with box privies which, apart from being an important cause of soil pollution, are believed to be otherwise instrumental in the dissemination of germs, *chiefly through the agency of flies.*"

The attention of all interested was riveted to the question of the agency of flies by the results of the investigations carried on during the Spanish-American War in 1898. In his first circular of directions to army surgeons, the Surgeon-General of the Army, Dr. George M. Sternberg, gave explicit directions regarding sinks, which, if followed carefully, would have prevented the spread of typhoid by flies, and he definitely

stated that no doubt typhoid fever and camp diarrhea are frequently communicated to soldiers in camp through the agency of flies which swarm about fecal matter and directly convey infectious material attached to their feet or contained in their excreta to the food which is exposed while being prepared at the common kitchen or while being served in the mess tent. These directions from the Surgeon-General, however, were ignored, with the result that the world got its first large-scale and convincing demonstration of the carriage of typhoid by flies, although the laboratory method was not used in this demonstration.

Inferential Proof

One of the volunteer surgeons, Dr. M. A. Veeder, who had already been interested in the subject, wrote articles before the close of 1898 calling attention to observations upon flies traveling back and forth between the latrines and the cooking tents in concentration camps in the Southern United States, and concluded that the conveyance of typhoid infection in the manner indicated "is the chief factor in decimating the army." Before Veeder's articles had been published, typhoid was rampant in many of the concentration camps, and an army typhoid commission was appointed in August of that year, consisting of Drs. Walter Reed, U. S. A.; Victor M. Vaughan, U. S. V.; and E. O. Shakespeare, U. S. V. These men were all of high scientific standing, the chairman being the now famous discoverer of the true etiology of yellow fever.

The investigation was thorough, and at the annual meeting of the American Medical Association in June, 1900, Doctor Vaughan presented a paper entitled "Conclusions Reached after a Study of Typhoid Fever among American Soldiers in 1898." This report comprised fifty-three categorical conclusions. The one relating to flies was as follows:

"27. *Flies undoubtedly served as carriers of the infection.*

"My reasons for believing that flies were active in the dissemination of typhoid may be stated as follows:

"a. Flies swarmed over infected fecal matter in the pits and then visited and fed upon the food prepared for the soldiers at the mess tents. In some instances where lime had recently been sprinkled over the contents of the pits, flies with their feet whitened with lime were seen walking over the food.

"b. Officers whose mess tents were protected by means of screens suffered proportionately less from typhoid fever than did those whose tents were not so protected.

"c. Typhoid fever gradually disappeared in the fall of 1898, with the approach of cold weather, and the consequent disabling of the fly.

"It is possible for the fly to carry the typhoid bacillus in two ways. In the first place, fecal matter containing the typhoid germ may adhere to the fly and be mechanically transported. In the second place, it is possible that the typhoid bacillus may be carried in the digestive

organs of the fly and may be deposited with its excrement."

There were many other important conclusions which bear upon the fly question. For example, it was shown that every regiment in the United States service in 1898 developed typhoid fever, nearly all of them within eight weeks after assembling in camps. It not only appeared in every regiment in the service, but it became epidemic both in small encampments of not more than one regiment and in the larger ones consisting of one or more corps. All encampments located in the Northern as well as in the Southern States exhibited typhoid in epidemic form. The miasmatic theory of the origin of typhoid fever and the pythogenic theory* were not supported by the investigations of the commission, but the doctrine of the specific origin of fever was confirmed. The conclusion was reached that the fever is disseminated by the transference of the excretions of an infected individual to the alimentary canals of others and that a man infected with typhoid fever may scatter the infection through every latrine or regiment before the disease is recognized in himself, while germs may be found in the excrement for a long time after the apparent complete recovery of the patient. Infected water was not an important factor in the spread of typhoid in the national encampments of 1898, but about

*This theory is founded upon the belief that the colon germ may undergo a ripening process by means of which its virulence is so increased and altered that it may be converted into the typhoid bacillus or at least may become the active agent in the causation of typhoid fever.

one-fifth of the soldiers in the national encampments in the United States during that summer developed this disease, while more than eighty per cent. of the total deaths were caused by typhoid.

About the same time that Doctor Vaughan's report was presented, Dr. R. H. Quill, in a "Report on an outbreak of Enteric Fever at Diyatalawa Camp, Ceylon, among the Second King's Royal Rifles during the period they acted as guard over the Boer prisoners of the war," stated that "during the whole period that enteric fever was rife in the Boer camp, flies in that camp amounted almost to a plague, the military camp being similarly infested, though to a lesser extent."

During the Boer War again and again the connection between flies and enteric fever was noted. Nuttall and Jepson have collected some significant quotations from different writers of that period. These may be quoted as follows:

"Tooth and Calverley (1901, p. 73), writing of typhoid in camps during the South African War, state that 'In a tent full of men, all apparently equally ill, one may almost pick out the enteric cases by the masses of flies that they attract. This was very noticeable at Modder River, for at that time there were in many tents men with severe sunstroke who resembled in some ways enteric patients, and it was remarkable to see how the flies passed over them to hover round and settle on the enterics. The moment an enteric patient put out his tongue, one or more flies would settle on it.'

"The authors further state that: 'At Bloemfontein

the flies were a perfect pest; they were everywhere, and in and on every article of food. It is impossible not to regard them as important factors in the dissemination of enteric fever. Our opinion is further strengthened by the fact that enteric fever in South Africa practically ceases every year with the cold weather, and this was the case at Bloemfontein. For though the days after 10 A.M. were as an English summer day, and the temperature in our tents was rarely below 70° and often about 80° F., the nights were very cold, and often frosty, and with the cold nights the flies disappeared. It seemed to us that the cold weather reduced the number of enteric cases by killing these pests.'

"Smith (1903), also writing of South Africa, states that a neglected trench 'becomes an open privy with an infected surface soil around it; the flies browse in it in the daytime and occupy the men's tents at night. On visiting a deserted camp during the recent campaign it was common to find half a dozen or so open latrines containing a fetid mass of excreta and maggots; this because the responsible persons so often failed to comply with the regulations for encampments by filling in latrines on the departure of the troops.'

"Austen (1904, p. 656) vividly recalls 'a latrine in a certain standing camp in South Africa during the late war, in which the conditions as regards flies were precisely as described by Major Smith. It is only fair to say that the ground was extremely hard and stony, so that very little soil was available for covering up the contents of the trench. On visiting the latrine

after it had been left undisturbed for a short time, a buzzing swarm of flies would suddenly arise from it with a noise faintly suggestive of the bursting of a percussion shrapnel shell. The latrine was certainly not more than one hundred yards from the nearest tents, if so much, and, at meal times, men's mess tins, etc., were always invaded by flies. A tin of jam incautiously left open for a few minutes became a seething mass of flies (chiefly *Pycnosoma chloropyga* Wied.), completely covering the contents.'

"F. Smith (1903, p. 331) refers to his experience in the South African War in seeing flies go from bed-pans to milk, etc., and discusses in detail methods of sewage disposal in warm countries."

Still later observations of a similar character have been made, not in war times but in times of peace, at army stations and encampments during practice maneuvers. A report by Maj. C. F. Wanhill on typhoid conditions in Bermuda, for example, shows that from 1893 to 1902 Bermuda had the highest enteric fever rate among the troops of any command occupied by British troops. Major Wanhill was placed in charge in 1904, and in two years almost wiped the disease out. He considered that carriage of the germs by flies was the most important mode of transfer.

With regard to the British army stations in India, the Journal of the Royal Army Medical Corps for the past six years has contained many suggestive and important articles written by different members of the Royal Army Medical Corps which emphasize to a strik-

ing degree the attention which is now being paid to the house fly and its near relative *Musca entæniata.* More or less definite proof of the connection between flies and enteric fever is given again and again and great attention has been paid to the question of latrines. For example, Lieut. Col. F. W. C. Jones (1907) uses the following phraseology: "Believing as we do that flies are the chief carriers of enteric fever in India, any plan which gets rid of them is worthy of consideration." And then the author proceeds to discuss the relative merits of incineration of excreta and other plans. Of course the officers of the army have control over their camps, but in India great difficulty has been experienced in enforcing the proper views upon high-caste natives.

Colonel Jones, in the article just cited, found a certain line of reasoning very useful, not only with high-caste native officers but with men on maneuvers. This consisted in an explanation of the meaning of the word *kakophagy,* which, being translated from the Greek, means excrement-eating. Colonel Jones writes. "I presume no one wishes to be a kakophagist; yet we are so in spite of ourselves, if flies bred in filth pits alight on our food just before we eat it." The high-caste officers at first looked upon sanitary measures as being only meant to worry them, but Colonel Jones got several of them together and to the best of his ability explained that men who took no precautions in camps to prevent the breeding of flies must of necessity be kakophagists. He found that this appealed to them most strongly, and

he had no further trouble. Does it not at once occur to the reader that to almost every American this objectionable term might with justice be applied?

Any quantity of inferential proof continues to accumulate. The Merchants' Association of New York has accumulated the opinions of many health officers and physicians as well as of entomologists and has published them in convincing form. At the December, 1910, meeting of the American Association for the Advancement of Science, at Minneapolis, Prof. F. L. Washburn gave a lecture entitled "The Typhoid Fly on the Minnesota Iron Range," in which he gave the results of a careful study of the conditions in certain mining towns in that State during the summer of 1910, in which the conditions were such as to make it perfectly plain that the main etiological factor in the typhoid epidemic then existing was *Musca domestica.*

The length of time that the typhoid bacillus will live in various substances from which it is likely to be carried by flies to food substances is important and has received some consideration. The length of time in which the bacillus will live in food substances, however, is even more deserving of consideration. Milk, commonly charged with the carriage of typhoid fever, is hardly of the greatest importance in this connection, since milk is such a short-lived food substance itself, although it is often contaminated with typhoid bacilli through the washing of the vessels which contain it

in contaminated water and by infected flies dropping into it.

When it comes to butter and cheese, however, we have long-lived foods, and the possibilities of their contamination by flies and their subsequent use is of especial interest, and more particularly as to the length of time that they will harbor virulent germs gained in this way or in any other.

Dr. John R. Mohler, of the Bureau of Animal Industry of the United States Department of Agriculture, informs the writer that investigations made in his office show that typhoid bacilli will live in butter under common market conditions for 151 days, and still be able to grow when transferred to suitable conditions. In milk under market conditions they retain active motility for twenty days, after which time there is a lessening in numbers until on the forty-third day of the test they disappear from view. At certain seasons of the year large numbers of flies collect upon the vats in which milk and cream are being stored in dairies and creameries; many flies fall in, their bodies being strained out when the cream is sent to the churn. If any of these flies carry typhoid bacilli these are washed off by the milk and remain in the butter or cheese made from it. Thus the eating of butter contaminated in this way may account for very many cases of typhoid fever the cause of which cannot otherwise be traced.

Exact Proof

From the laboratory point of view, a number of exact experiments have been made, and we quote the following paragraphs from Nuttall and Jepson:

"Celli (1888) fed flies with pure cultures of the *Bacillus typhosus* and examined their contents and dejections microscopically and culturally. Inoculations on animals were also made, proving, as he supposed, that the bacilli which passed through flies were virulent. (He made similar observations with the *Spirillum* Finkler-Prior.)

"As Ficker (1903, p. 274) properly points out, Celli's statement has less value to-day, since at the time he carried out his experiments no suitable means existed for properly differentiating *B. typhosus* from other organisms of similar character.

"Firth and Horrocks (1902) kept *M. domestica* (also blue-bottles) in a large box measuring four by three feet, with one side made of glass. They were fed on material contaminated with cultures of *B. typhosus*. Agar plates, litmus, glucose broth, and a sheet of clean paper were at the same time exposed in the box. After a few days the plates and broth were removed and incubated with a positive result. The flies' excreta on the paper yielded *B. coli* almost in pure culture. In a second experiment some fresh typhoid stool to which a typhoid culture had been added was dusted with earth and served as the infective material; colonies of *B. typhosus* appeared on the plates. In a

third experiment the infected flies were captured and killed. By means of sterile forceps their heads, wings, legs, and bodies were separated and respectively placed in sterile broth. Sub-cultures of the broth all gave a positive result. The authors conclude that *M. domestica* can convey *B. typhosus* from infected sources to objects upon which they walk, rest, or feed, and that bacilli adhere to the external parts of flies. 'It has not been proved that the enteric bacillus passes through the digestive tract of the fly.'

"Hamilton (II. 1903) in Chicago, caught eighteen flies in and about houses and rooms occupied by typhoid cases, and states that she found *B. typhosus* in five of them.

"Ficker (1903) caught flies in a house in Leipzig where eight cases of typhoid had occurred. He isolated *B. typhosus* from the flies. He carried out experiments with *M. domestica* kept in ten-liter flasks into which he introduced some sugar, strips of filter paper, and culture of typhoid bacilli in bouillon. This was spread on the glass and partly absorbed by the filter paper. After eighteen to twenty-four hours the flies were transferred to clean flasks. He found the flies to survive over four weeks in captivity if protected from the cold and fed on sugar, bread and water, or milk. He notes that flies may all die during a cold night, irrespective of typhoid bacilli being present in their food. The flies were transferred to clean flasks every two or three days. The flies to be examined were etherized and rubbed up in a mortar—the crushed material being

used for making the plates on gelatin and special media. *B. typhosus* was recovered from the flies twenty-three days after they had been infected.

"Buchanan (1907) allowed *M. domestica* to walk over the surface of a Petri dish smeared with typhoid dejections. The flies (number?) were immediately afterwards allowed to walk over the surface of media in Petri dishes. Naturally, some plates became infected.

"The evidence regarding the part that flies may play in the spread of typhoid fever may therefore be accepted as quite conclusive."

In addition to the experiments by Nuttall and Jepson given above should be mentioned the experiments recorded by Major N. Faichnie (1909). Major Faichnie states that he was recently sent to investigate a small outbreak of enteric fever at Kamptee, where he was obliged to suspect flies, after excluding all other causes. Flies were not over-numerous, but twelve from the artillery lines were mashed up in sterile salt solution, and *Bacillus typhosus* was separated. Twelve flies from the infantry kitchen were then captured. Each was transfixed with a sterile needle, passed two or three times through a flame until the legs and wings were scorched, and was then put in a normal salt solution and stirred. After this they were mashed up and *B. typhosus* was found. Before mashing it was not found. The demonstration that the bacillus was present in the intestines was therefore good. His conclusions are that while experience seems to show that infection con-

veyed by flies' legs is not common in times of peace, "infection by the excrement of flies bred in infected material explains many conclusions formerly difficult to accept."

Chronic Carriers

It becomes necessary at this stage to discuss the question of persons who become chronic carriers of typhoid germs, giving them out in their excreta and in their urine for perhaps many years. The application of this phenomenon to the fly question will be dealt with later. It was known in the United States prior to the Spanish-American War that typhoid patients would give out bacilli in this way before the disease was diagnosed, and it was also known that some of them would give out the germs for perhaps several weeks after the fever abated and the patient was practically cured. And of course the walking typhoid or "ambulatory enteric" was known to exist; that is to say, slight cases which did not bring the patient to bed but during which germs must have been given off. True chronic carriers were not known in this country at that time, and the development of this extremely important phase of the typhoid question has been a recent one. The phenomenon was known in Germany before it was brought vividly to the attention of the American people.

The first case here to receive general notice was that of "Typhoid Mary," an Irish cook, who was discovered by Dr. George A. Soper, of New York. She had been cook with a family on Long Island, and during the summer of 1906 several cases of typhoid occurred. The

writer was consulted, and advised that Doctor Soper be called in to make a thorough investigation. The results of Doctor Soper's search were most interesting. After studying every possible source with absolutely negative results, the proper examinations were begun, and it was discovered that Mary, the cook, was a chronic carrier. Her past history was looked into, and it was found that for several years there had been typhoid cases in nearly every family who had engaged her. She was immediately isolated, and kept in custody for three years. Then she was released, promising never again to engage as cook and to report at frequent intervals. She returned after four months saying that she could get no work and was placed by the New York City Department of Health in one of the laundries of a public institution, where she still remains.

Much space was devoted to accounts of this case in the daily newspapers and other publications at the time, and about that time and subsequently many investigators began to look into the general subject of typhoid carriers, with remarkable results. For example, a dairy maid was found at Killworth, England, in 1909, through the investigations which followed a typhoid outbreak. It was discovered that she had had the fever in 1903, and that families with whom she subsequently lived had typhoid cases. Finally she became attached to a dairy which furnished milk to an army post, and when the milk was not boiled many cases of typhoid resulted.

In another instance an epidemic of typhoid in the

Tenth German Army Corps in the summer of 1909 was traced to a chronic carrier in the case of a woman who prepared vegetables and who had assisted in the preparation of vegetable salads. The typhoid bacillus grows on the surface of potatoes readily, and this accounted for the outbreak, on the necessary supposition that the woman was of uncleanly habits. The curious point in this case was that she had had typhoid thirty-six years previously for the only time. In the same summer there was an epidemic of the fever in Georgetown, D. C. This was traced by milk routes to a certain milk dealer, who was a woman and who on examination was shown to be a chronic carrier.

In the same year, Aldrich, in the Journal of the Royal Army Medical Corps for September, page 225, made the generalization that the combined observations of a large number of investigators in various countries showed that about three per cent. of the convalescent typhoid patients become chronic carriers, and of these eighty per cent. are women. About this time the German Government conducted an anti-typhoid campaign in Southwest Germany, and in his report Klinger showed that 400 chronic carriers were found and that there were probably others.

Earlier than this, Dr. W. G. Savage (1907) made three points of interest in this connection: (1) Typhoid bacilli are frequently excreted in the urine in about twenty per cent of the cases, but the obvious practical measures resulting from this knowledge are not habitually taken. (2) Typhoid bacilli may persist

in the body and be found in the feces and gall bladder long after all clinical symptoms have ceased; it appears that women form a large percentage of chronic bacilli carriers; sixteen out of twenty-two cases (Lutz) and nine out of twelve cases (Klinger). (3) Typhoid bacilli may be found in the excreta of healthy persons who have apparently never suffered from typhoid fever; they have been in contact with cases of typhoid and are analogous to the contact cases of diphtheria outbreaks.

Nature, in a review of scientific memoirs by officers of the Medical and Sanitary Departments of the Government in India, No. 32, Calcutta, 1908 (Review, *Nature,* November 5, 1908, p. 21), shows, as a result of this Indian work, that the typhoid bacillus continues to be excreted for long periods in the urine and feces of a certain percentage of patients convalescent from enteric fever, the number in the urine being very large and the excretion being markedly intermittent. The general conclusion arrived at was that the problem of the prevention of enteric fever among the British troops in India is the detection and isolation of the individual harboring the *Bacillus typhosus.*

As a matter of course, the typhoid patient himself is a much more frequent cause of infection than the healthy typhoid carrier. Klinger, in the report of the anti-typhoid campaign in Southwest Germany, previously referred to, found that the typhoid patient was the source of infection in 1,272 cases and the healthy typhoid carrier in 125 cases. He concluded therefore

that typhoid patients should be considered the chief source and that this was due to their being not only more numerous than the carriers, but also to the fact that the germs passed by them are usually more dangerous. On the other hand, every infection by a typhoid carrier may be the first in a long series of cases; in fact, he may be responsible for a whole epidemic. His importance cannot be over-estimated. As Klinger says, "He is an important factor, and typhoid houses and typhoid areas seem to be his work."

In an article in the Boston Medical and Surgical Journal* we find the following very interesting statements and reports of cases of this sort, that mentioned in the final paragraph evidently being Typhoid Mary:

"It is asserted by Kutscher that, in Southwestern Germany, direct contact is a more important factor in the spread of typhoid fever than polluted water, and that about four per cent. of typhoid patients become chronic carriers of the specific bacilli, which they excrete in both urine and feces, sometimes for long periods. Doerr, for example, cites cases reported by Drober and Hunner, in which the bacilli were isolated from the gall bladder seventeen and twenty years after recovery, and Lentz asserts that if after ten weeks from convalescence the excretion of the bacilli has not ceased, it will most likely continue permanently and uninterruptedly, in spite of medication. He cites a number of cases in which, after ten, thirty, and even forty-two

*The exact reference to this important article has been lost and cannot be found.

years after recovery, the excretion continued. Levy and Kayser report that in the autumn of 1905 a number of cases of typhoid fever occurred in an insane asylum, in which two years previously an inmate had had the disease and had recovered. On the appearance of these later cases, this person was examined and was found to be excreting the bacilli in her feces. Further examinations were made at intervals of several weeks, and the bacilli were found ten times. In October, 1906, she died of a typhoid bacillary septicemia, due to auto-infection from the gall bladder; and on autopsy the bacilli were isolated from the spleen, liver, bile, wall of the gall bladder and from the interior of a large gall-stone.

"A somewhat similar case is reported by Nieter and Liefmann, also from an insane asylum in which the disease had been endemic for many months. A patient dead of chronic dysentery was examined and typhoid bacilli were found in the intestines and in pure culture in the gall bladder, in which were gall-stones. Among 250 inmates were found seven typhoid carriers.

"Klinger found, among 1,700 persons, twenty-three typhoid carriers, ranging in age from eighteen months to sixty years, eleven of whom had no typhoid history. Of 842 convalescents from the disease, sixty-three, or thirteen and one-tenth per cent. were found to be excreting the bacilli, and eight were still doing so six weeks after recovery.

"Kayser, tracing outbreaks to their sources, found a boy of twelve years, a member of a milkman's fam-

ily, to be a chronic carrier and the probable source of infection in a number of cases. Another outbreak in which seventeen persons were seized (two deaths) was traced to a woman who had no typhoid history but was excreting the specific bacilli. She was employed in the dairy from which the persons seized had obtained their milk. Of 260 cases of typhoid fever investigated, sixty were traced to infected milk. Among the sixty victims were thirty maids and kitchen girls, twelve bakers and forty-four persons engaged more or less in kitchen work. In all, twenty-eight cases were traced directly to apparently healthy typhoid carriers.

"Minelli examined 250 prisoners who had not been in contact with typhoid cases, and found but one who had the specific organism constantly in the feces. The agglutinative test was positive.

"Etienne and Thiry report the case of a man, sixty-four years of age, who, after four years in a hospital, under treatment for tabes and hemiplegia, had two attacks of jaundice, and on examination was found to be excreting typhoid bacilli in the feces.

"A series of twenty-six cases of the disease in fifteen families of a village in Lorraine is described by Seige, who states that diligent investigation by the district physician, the village authorities and the Bacteriological Institute of Saarlouis placed the responsibility upon a woman who was a chronic typhoid carrier.

"An interesting case of infection from direct contact is reported by Dr. H. MacKenzie and by Mr. W. H. Battle. More than two years after a severe attack of

typhoid fever, a man had an attack of femoral osteomyelitis, caused by *B. typhosus*. After operation the patient was discharged, but some time afterwards a sinus formed, the purulent discharge from which contained typhoid bacilli. The patient's wife had not been in contact with any other case, but frequently removed and burned the dressings. After a time she fell sick with typhoid fever, and died.

"In a letter to the writer, under date of April 3, 1907, in response to a request for information concerning a woman described in the press as a 'typhoid factory' and held under detention by the Department of Health of the city of New York, Dr. Walter Bensel says: 'The woman of whom you write has given a history of a probable mild attack of typhoid fever about six years ago. Since that time there have been undoubtedly twenty-eight cases of typhoid fever in the families in which she worked. The number of cases occurring in a family within a few weeks of her advent varied from one or two up to six out of seven members. The evidence seemed so strong that she was a carrier of typhoid fever that she was removed to Reception Hospital by force. Examinations of her feces and urine were made, and the typhoid bacilli found in her feces confirmed positively our suspicions with regard to the possibility of her conveying typhoid fever.' "

Maj. J. C. Morgan and Capt. D. Harvey, Royal Army Medical Corps (1909), give an account of investigations which they had made on the viability of the typhoid bacillus as excreted under natural conditions

by the chronic carrier. As it happens, they had several cases of chronic carriers under observation. In their first experiment, typhoid bacilli were recovered from polluted soil six hours after pollution, but thirty hours after none could be recovered. In a second experiment, bacilli were recovered five and one-half hours from soil pollution. In a third experiment, bacilli were recovered five hours after pollution, and again thirty hours after pollution of the soil; none later. In a fourth experiment, bacilli were recovered twenty-four hours after contamination.

The sixth and seventh experiments were made with toweling, to indicate the viability of the typhoid bacillus on cotton fabrics. A piece of toweling was soaked in a sample of urine which was found to contain 50,000 bacilli per cc. It was then cut into pieces and put into petri dishes, with the result that bacilli were found upon some of the pieces up to and including the fourth day after pollution, where the pieces had been exposed to daylight. Pieces kept in the dark were found to be infested with living bacilli up to and including the eleventh day.

In another experiment, one of the carriers voided his excrement in a dry-earth latrine, with the result that it was found that, under the conditions of a dry-earth closet and of dry-earth methods of disposing of excreta, typhoid bacilli can readily be recovered up to a week, and can exist in the interior of a dry fecal mass up to eighteen days. This indicates, say the writers, how easily the infection could be conveyed

by flies from such material when left exposed in a latrine pan.

Another experiment, with a woolen blanket smeared with a fresh sample of feces from a carrier and doubled so that the smear was outside, gave the result that the bacillus was recovered at every examination up to and including the fortieth day. In this experiment the sample used was a liquid stool, the result of a saline aperient, and portions of the blanket fiber were pulled out from the soiled portion and used for the experiment.

The latest contribution to the subject at this time of writing is Dr. J. C. G. Ledingham's report (1910). In an introduction to this report, Dr. Theodore Wilson states that the difficulty of dealing with carriers is very great indeed, since they may harbor the infection for long periods and it is extremely difficult to free them from it. It is most important, however, that all possible efforts should be made to detect carriers and to endeavor to secure on their part those precautions of strict personal cleanliness and of disposal of dejecta which will minimize the risk of infecting other people. Furthermore, Doctor Thompson points out that it is equally important that an attempt should be made to prevent such carriers from taking any part in the milk trade or in the preparation or handling of food.

An excellent review of Dr. Ledingham's report by Dr. R. M. Grimm will be found in Public Health Reports xxvi, No. 4, March 17, 1911.

Influence of Flies in the Carriage of Typhoid in Cities

Much of what we have just written refers to the carriage of typhoid by flies in encampments of troops and, in such facts as we have given about the Spanish-American War and the Boer War, to their effective carriage in temporary camps. We have equally shown their influence, however, at more or less permanent army posts and the certainty of the inference under these conditions is acknowledged by practically every one. And the same free acknowledgment must be made in the case of any emergency which calls together for temporary purposes large bodies of men, engaged on great public works, for example, as the Panama Canal or the construction of great reservoirs, or in mining camps. Any slight lack of care in the disposal of excreta under such conditions almost invariably brings about an outbreak of typhoid, and most often by the carriage of the causative organism by flies. But does the same thing hold for cities? The opinion of a certain class of conservative medical men on this point is well expressed in a recent editorial in the Journal of the American Medical Association, as follows:

"It is sometimes easier to implant a new idea in the human mind than to extract it or modify it when it has once taken firm root. The notion that bad smells from faulty sewers give rise to specific infections, such as diphtheria and typhoid fever, or that piles of garbage 'breed disease,' are cases in point. In the public mind, methods of garbage disposal and elaborate

plumbing ordinances often loom large as the chief weapons of combating disease. Too often attention is diverted from really significant and tangible dangers to health by the cry that the garbage dump or the sewage manhole is emitting vile odors. It is of course well known to physicians that there is no evidence that disease can be spread by odors, although foul air may possibly impair health and render the body less resistant to disease.

"Many sanitarians are beginning to fear that a similar misapplication or misunderstanding of the relation of the house fly to typhoid fever is coming about. No one questions that the house fly is an unmitigated nuisance. Neither is there any doubt that under certain conditions, such as prevail in military or mining camps or on many a country farm, or even in cities that allow the crude type of privy, the house fly is an exceedingly important agent in the transmission of infection. This has been abundantly proved. There is observable, however, a tendency to assume a connection much wider than this and to attribute to fly infection a portion, sometimes the major portion, of the typhoid fever occurring in large and well-sewered cities.

"Several instances of this misguided enthusiasm have come to notice within the last few months. It need hardly be pointed out that the house fly, no matter how disgusting its origin or habits, cannot convey the specific germ of typhoid fever to any food substance unless it has access both to food substances and to typhoid germ. Those amateur investigators who assume that

they have discovered the origin of a typhoid epidemic if they observe a few piles of horse manure in the alleys of a city take a wide leap over logical difficulties. Their mode of reasoning seems to be this: Flies can breed in horse dung, flies can convey typhoid fever, therefore flies bred in these dung heaps have caused or are about to cause typhoid fever. One other essential condition, namely, the existence of infected material to which the flies have access, is left out of account in such hasty judgments.

"As a matter of fact, grave as is the danger of fly transmission of typhoid under rural conditions, it does not seem to be an important factor in the production of urban typhoid. As is well known, the intensive study of typhoid fever in Washington, D. C., which extended over several years, yielded no evidence that fly transmission had any noteworthy share in typhoid fever causation in that city.

"One of the most experienced American health officers has taken a decided stand on this question in a book recently published.* While recognizing the desirability of treating garbage in such a way as to prevent a nuisance, and admitting the possibility of fly-borne infection where open privy vaults exist, he declares very plainly that 'there is no evidence that in the average city the house fly is a factor of great moment in the dissemination of disease.' There can be no doubt that in any reasonably clean and well-

*Chapin, Charles V.: Sources and Modes of Infection. New York. 1910.

sewered city the cases of typhoid infection due to direct fly transmission are relatively very few compared with the number due to water, to milk and to contact (including contact with carriers). As one writer has said, in discussing this question, 'We need more scientific knowledge and less repetitious babble of sentiment in dealing with flies or any other nuisance.' "

Such ideas as this are likely to do harm. From every point of view it is desirable to rid communities from flies, and the only danger of over-emphasizing the importance of the typhoid fly in its relation to typhoid fever is that it may be accepted as the principal cause of the spread of the disease in certain cases where careful investigation would indicate other and perhaps easily controllable causes. Therefore, while we are inclined to agree with the writer of the editorial that statements should be cautious to a reasonable extent, the general tone of the editorial undoubtedly far too greatly minimizes the importance of flies from the disease point of view in modern cities.

Reference is made to "any reasonably clean and well-sewered city." The city of Washington has the reputation of being perhaps the cleanest and best-sewered city in the United States, and yet it is possible any summer morning to find human dejecta in alleyways and vacant lots deposited there over night by irresponsible persons, and in the light of day swarming with flies. In the poor quarters of the city uncared-for children of the indigent ease themselves almost wherever

they happen to be.* The writer has shown that the typhoid fly oviposits upon such individual dejecta and that its larvæ successfully breed in them, and that the adult flies of the next generation issue from them under the ordinary summer moisture conditions that prevail in Washington.† With the now well-known percentage of chronic typhoid carriers (from three to four per cent.) and with the hundreds of cases of typhoid that have occurred annually in the city of Washington during the past ten years, and with the existence as actually observed of such loose and ill-placed dejecta, and with flies feeding upon them and breeding in them within short distances from unprotected kitchens and pantries, to say nothing of markets and food shops, how is it possible that flies should be factors of no great moment? Surely there must be scores of typhoid carriers living in Washington to-day.

Moreover, there still exists in portions of even the cleanly city of Washington the uncared-for box-privy nuisance. The judgment in this case is not hasty. It

*This occurs in every city. Newstead in his Liverpool (England) report writes: "In the course of my investigations, more especially on hot days, numbers of house flies were seen hovering over or feeding on such matter [human droppings]. The feces were generally those of children, and were lying, as a rule, a few feet from the doorways, in the courts or in the passages behind the houses. In one instance no less than five patches of human excreta were lying in one court, and all of them were attended by house flies."

†The exact records of these experiments and rearings will be found in the writer's 1900 paper. The especial cases in point are mentioned on p. 572, as many as thirty-one house flies being reared from a single dropping of a child. We have elsewhere mentioned Major Faichnie's record of the rearing of 500 flies from a single dropping.

may be difficult to prove directly and to the laboratory man that any certain percentage of typhoid cases are caused in this way, but how much more difficult will it be to prove that they are not? And is not a great preponderance of such evidence as we have in favor of the conclusion that house flies are great dangers even in cities as well cared for as the best of our American cities?

As to the "repetitious babble of sentiment in dealing with flies," is it not a mistake to apply such words to a conscientious effort to warn the public of a danger which surely exists under certain conditions and most probably exists in all?

It was stated in the editorial which we are considering that the intensive study of typhoid fever in Washington, D. C., which extended over several years yielded no evidence that fly transmission had any noteworthy share in typhoid causation in the city. This statement was based largely upon the fact that the fever for the most part was absent or rare in portions of the city where the box-privy nuisance still exists (and it should be stated that the health officer has every one of these nuisances carefully marked on a map) and that an effort made during the summer of 1908 to ascertain whether there was any relation between the curve of typhoid increase and the curve of fly increase resulted in apparent failure.

The effort was undertaken by the Bureau of Entomology of the U. S. Department of Agriculture in co-operation with the Public Health and Marine-Hos-

pital Service. The fly gatherings were begun about June 19th and continued to October 19th, having covered a period of four of the hottest months in the season and those in which flies are most troublesome. The method used was to supply such of the members of the Bureau force as lived in distinct and separate sections of the city with a quantity of sticky fly paper with instructions to expose a sheet every other day for a period of forty-eight hours. The sheets were then returned to the Bureau and the flies carefully counted and recorded upon specially prepared cards bearing address and date of each exposure, together with such data as could be secured concerning the conditions of nearby stables and manure heaps. Certain parts of the city, among the slums and along the water front, were not reached by the regular employés of the Bureau, but, that these sections might be represented in the report, two assistants were detailed for the purpose and made regular rounds on bicycles, collecting fly-laden sheets and leaving fresh paper three times a week. Sunday, of course, was a day of rest, and this fact interfered to some extent with the counts, since in case of papers exposed in meat shops and restaurants flies were usually so plentiful that the maximum catching capacity of the paper was reached within forty-eight hours.

Sixty-two stations were located throughout the city. At the end of the season the results were tabulated and the curve of increase was plotted. At the same time the Public Health and Marine-Hospital Service had

been plotting the curve of typhoid prevalence, and on comparison it was found impossible to derive any distinct connection between the two curves—such connection as would be suggestive of cause and effect.

During the summer of 1909 a series of investigations of a very similar character was carried on in Providence, R. I., by Prof. G. F. Sykes (1910), of Brown University. The conclusions reached by him were as follows: (1) Fly nuisance is local. (2) Geographic distribution of pestiferous flies is determined by local sanitary conditions. (3) The seasonal distribution is conditioned by meteorological influences (temperature and sunshine). (4) Over ninety-nine per cent. of the flies caught were *Musca domestica,* the remaining fractional per cent. being *Lucilia cæsar.* (5) The plotted curve for typhoid cases did not show a close relation to the fly curve, but did show a close parallel to the temperature curve. (6) The high-water mark for deaths from diarrhea antedated that for the fly season by fully three weeks, and followed from one to two weeks after a noticeable rise in temperature.. (7) The geographic distribution of typhoid cases over the city was largely independent of areas known as "unsanitary" and as "fly centers."

It is to be mentioned that the flies caught by Professor Sykes were collected in three kitchens, the Washington observations covering sixty-two stations.

It is possible that Doctor Chapin, of Providence, the writer referred to in the editorial under consideration, was confirmed in his opinion by the result of Professor

Sykes's observations in his own home city, but nevertheless Doctor Chapin is a well-known man of high scientific standing and his conclusions must be viewed with all respect. When we come to analyze the situation, however, it becomes at once apparent that in cities the correlation or non-correlation of the curve of house fly abundance and of the abundance of typhoid has practically no effect upon our conclusions as regards the possible transfer of the disease by flies.

Flies are numerous at all times during the summer, and wherever excreta carrying virulent germs can be reached by them it is sure to be covered by them—whether in early June or in October—and the chances are almost as great that food supplies will be reached by these flies whether there are 500 of them or 600 of them. The fact that typhoid fever does not develop in localities where flies are most numerous does not mean that it is not carried by flies, but simply means that the flies in that locality have had no opportunity to visit substances containing virulent germs. A correlation of the two curves in question has been found by Doctor Jackson in his report to the Merchants' Association of New York, and it has been found by Captain Ainsworth in his studies of the house fly and enteric fever in India, by Purdy (1910) in New Zealand, and by Osmond (1909) in Cincinnati, and where it is coincident it may serve to attract the attention of people to the subject, but the absence of the correlation in any given case is a most inconclusive argument.

A most careful and thoroughly scientific study of the seasonal prevalence of typhoid has been made by Sedgwick and Winslow (1902). Their investigation included an examination of the published data for all countries. They conclude that the increase of typhoid with a gradual rise in the mean air temperature is so widespread and significant as to indicate an undoubted relationship. There is no doubt that a similar rise of temperature hastens the rapidity of breeding of the house fly until at the culmination of the heated term they are present in countless numbers, as we have seen. This fact was fully appreciated by Sedgwick and Winslow, who in their conclusions use the following words:

"Of the three great intermediaries of typhoid transmission, fingers, food, and flies, the last is even more significant than the others in relation to seasonal variation. * * * There can be little doubt that many of the so-called 'sporadic' cases of typhoid fever, which are so difficult for the sanitarian to explain, are conditioned by the passage of a fly from an infected vault to an unprotected table or an open larder. The relation of this factor to the season is of course close and complete: and a certain amount of the autumnal excess of fever is undoubtedly traceable to the presence of large numbers of flies and to the opportunities for their pernicious activity."

The real explanation, according to these authors, of the seasonal variations of typhoid fever is a direct effect of temperature upon the persistence in nature of germs which proceed from previous victims of disease.

This, of course, means that there are more typhoid germs in late summer and autumn, and as there are at the same time more flies to carry them, the necessity of destroying flies, especially in the early summer, is emphasized by this conclusion.

Other Points

It may be that enough has been said on the subject of the carriage of typhoid by flies, but there is a great deal of evidence that has not been touched upon at all. Dr. J. W. Palmer of Ailey, Ga., for example, who has had much experience with typhoid in a region for the most part agricultural, although in a rich part of the State of Georgia, informed the writer in the autumn of 1910 that in order to emphasize the importance of flies in the distribution of this disease and to carry conviction to his patients as to the necessity of screening their houses and avoiding flies, he promises to treat without charge all cases of typhoid fever that develop in houses well protected from flies, and states that he has never had a case develop in such a house.

In the Transactions of the Medical Association of Georgia for 1910, an article by Doctor Palmer is published on pages 149 to 157. In this paper he states that he estimates that ninety-five per cent. of the typhoid fever in rural districts may be laid to the typhoid fly. He states that during the past typhoid season he treated fever in several families, and especially noticed that in the families which controlled the flies as directed by him no new cases developed, while families

which did not control the flies had anywhere from one to four cases in each family. He points out that in one year typhoid causes more deaths than yellow fever in fifty years.

The Georgia State Medical Association as early as April, 1909, appointed an executive committee of five, known as the "Fly Committee," and this committee appointed a sub-committee consisting of one member from each county, whose duty it has been to give public lectures on the dangers of the common house fly, especially in every public school in their respective counties.

Capt. R. B. Ainsworth, of the Royal Army Medical Corps (1909), gives an admirable summary of important observations in India, from which he concludes that flies are of the greatest importance. He refers to much the same general tone of the medical profession as that indicated in the quoted editorial in our previous section. He writes, "Notwithstanding the fact that much has been written of late regarding the life history and habits of the common house fly, and many suggestions made relative to its possibilities as a disease carrier, it is to be feared that the general tone of the medical profession with regard to the question is apathetic if not actually antagonistic. The latter is distinctly in evidence in a rider to the recent reports of the Simla Enteric Fever Committee, added by some members thereof, though why they should dissent so emphatically in the face of so rapidly accumulating proof is hard to understand."

After his summary of the whole situation, Captain

Ainsworth concludes, "It seems to me that enteric prevention naturally groups itself under five headings, namely, (1) Isolation of the human carrier, failing (2) elimination of the bacillus by means of some drug as yet undiscovered; (3) rendering excreta innoxious by disinfection, water carriage, and similar sanitary measures; (4) the establishment of immunity; and (5) the destruction of the go-between, to wit, the fly."

Cholera

One of the earliest accurate scientific studies of the agency of insects in the transfer of human diseases was with regard to flies as spreaders of cholera. The belief in this agency long preceded its actual proof. Dr. George E. Nicholas (1873) is quoted by Nuttall as writing as follows regarding the cholera prevailing at Malta in 1849:

"My first impression of the possibility of the transfer of the disease by flies was derived from the observation of the manner in which these voracious creatures, present in great numbers, and having equal access to the dejections and food of the patients, gorged themselves indiscriminately and then disgorged themselves on the food and drinking utensils. In 1850 the 'Superb,' in common with the rest of the Mediterranean squadron, was at sea for nearly six months; during the greater part of the time she had cholera on board. On putting to sea the flies were in great force; but after a time the flies gradually disappeared, and the epidemic slowly subsided. On going into Malta harbor, but

without communicating with the shore, the flies returned in greater force, and the cholera also with increased violence. After more cruising at sea, the flies disappeared gradually with the subsidence of the disease."

C. Flugge is said by Nuttall and Jepson to have expressed his belief in 1886 that flies may infect the food in cholera times. Their numbers vary extraordinarily at times and in certain places. They must play an important part, especially when they are numerous. He drew attention to the fact that the worst cholera months are those in which insects abound.

Dr. J. Tsuzuki, of the Japanese Army Medical Service, writing in 1904 upon his researches during the cholera epidemic in North China in 1902, stated that flies in China are a terrible infliction to the stranger, and that if they are capable of carrying the cholera germ they must play an important part in the spread of the disease. He captured flies in Tientsin in houses in which there were cholera patients, and succeeded in isolating cholera vibrios from them. He also placed flies in a cage with a cholera culture and a dish containing sterilized agar, with the result that cholera colonies developed upon the agar.

But this was not the first definite and conclusive experiment in this regard, since Nuttall and Jepson point out that something had been done in 1886 by two Italian physicians in Bologna, and that Sawtchenko, of St. Petersburg, in 1892, found that when flies had fed for some time on a cholera culture almost no other

bacteria could be isolated from their dejections. In the same year M. Simmonds studied the flies in a hospital in Hamburg, especially those present in the postmortem room, where many bodies and intestines of persons dead of cholera were lying. He was able to isolate cholera vibrios from the first fly caught. He had the room cleaned at once, and after this was unable to obtain cholera germs from flies caught. He found that healthy, active cultures could be made from flies for an hour and a half after they had visited infected material.

Much the same work was done in that year and subsequent years by Uffelmann, and in 1905 Chantemesse succeeded in isolating cholera vibrios from the feet of flies seventeen hours after they had been contaminated. In 1908 Ganon stated that flies can transmit infection for at least twenty-four hours after a meal of infected material, and showed that that period is sufficient to allow them to be carried for a long distance in railway trains. Nuttall and Jepson point out that the various experiments made during this period gain in value from the fact that the investigators were to a large extent ignorant of the work done by others, and they add that a number of authors, without contributing any personal evidence on the subject, express their conviction that the house fly carries cholera. They consider that the body of evidence which they present as to the part played by flies in the dissemination of cholera appears to be quite convincing.

An interesting and important piece of work in this

direction was done by Surgeon Major R. Macrae (1894), the civil surgeon of Gaya, India, at the time of an outbreak of cholera in the jail at that place. He had in the case of the jail at Gaya a definite structure composed of eight yards, and thus his observations were condensed, and his medical authority enabled him to control the situation to a sufficient extent to prove his conclusions to his satisfaction and practically to that of every one else. With much detail he gives a map of the jail enclosures and a description of them, together with an account of the distribution of the prisoners. The cholera outbreak was under his charge and thorough examinations were made of all of the possible means of spread. The water supply was shown to be above suspicion. The milk was of excellent quality and the food as well. A high wall separated the male department from that of the females and cut off the fly infection; no cases of cholera occurring in the female side. As Macrae states: "It was observed before the epidemic occurred that the jail was infested with a plague of flies; disinfectants of various kinds were used, but they could not be got rid of. The moist, steaming weather appeared to favor their development. They were present in swarms when the disease broke out, and it was an observation of daily occurrence to see them settling on cholera stools wherever possible. *The rest can be imagined!* As soon as feeding time arrived and the food was distributed in the usual way on open iron plates on the feeding platforms, there was at once a crowding of flies towards the platforms, and

a struggle between them and the prisoners for the food. An active prisoner might possibly be able to protect his plate from contact with them; but many are careless and do not seem to mind much." Actual experiments were made by exposing boiled milk; and that exposed on the male side became infected with the cholera germ. In conclusion, Macrae writes:

"The practical lesson the experiments teach is, that flies should be looked upon in the light of poisonous agencies of the worst kind during cholera epidemics, as it is clear that if they find access to poison they will carry and distribute it, and every possible means should be taken to prevent their getting into contact with either food or drink of any kind, and to those having to deal with large bodies of men it is a lesson more easily learnt than put into practice."

Another interesting instance of a somewhat similar nature is cited by Nuttall and Jepson, in which they state that W. T. Buchanan, in 1897, described a jail epidemic which occurred at Burdwan in June, 1896. This was also the case of a prison. Outside of the prison there were some huts where cholera prevailed. It is said that a strong wind blew great numbers of flies from the side where these huts were into the prison enclosure, where they settled on the food of the prisoners. It resulted that only those prisoners who were fed at the jail enclosure nearest the huts came down with cholera, while the others remained healthy.

Dysentery

The probability of the carriage of dysentery as an intestinal disease has been suggested by several writers and especially by medical officers of the English army in India, and two of these were referred to by Nuttall and Jepson in 1909, but at that time these authors were obliged to state that there was no direct evidence bearing upon flies in relation to dysentery. Since the publication of their abstract of the literature, however, an important paper has been published by Orton and Dodge (1910). We have previously referred to this paper under the heading "Substances in which the early life is passed."

It seems that during 1910 an epidemic of 136 cases of bacillary dysentery occurred in the Worcester State Hospital and Doctor Orton found that the epidemic had spread gradually. It was not characterized by a sudden general series of cases. This, of course, argued against the theory of a water-supply infection, and it also argued equally well against milk infection and infection from raw foodstuffs. It is obvious that with infection from any of these sources a large number of patients would have become ill at the same time. House flies were unusually abundant in the hospital in spite of screening, and these were considered to be the carriers of the dysentery. We have elsewhere shown that it was finally discovered that the unusual number of the flies was due to certain piles of spent hops and barley malt which had been hauled in as fertilizer on the grounds near the buildings.

The case reported is interesting and unusual on account of the fact that the hospital in question is a hospital for the insane, and that it is impossible in such an institution to control the intestinal discharges of the patients and confine them to one place. In the hospital all bedding and clothing were brought for cleaning to the laundry, and the laundry contained many flies, and in the laundry colonies of *Bacillus prodigiosus* were exposed under experimental conditions. Subsequently at varying intervals flies were caught in the other rooms of the hospital, and upon test from a large number of them cultures of the Bacillus were had.

Doctor Orton's conclusion as published is that flies were entirely responsible for the epidemic. It is rather a pity that the causative organism of the dysentery could not have been used in this experiment, but that was of course impossible on account of the danger, and it is altogether probable that Doctor Orton's conclusions from his experiments with the other Bacillus were perfectly correct.

Dr. C. W. Stiles tells the writer that the causative organism of amœbic dysentery sporulates more readily as the feces dry. Therefore under a dry-privy system this disease is the more likely to be carried by flies.

Diarrhea in Infants

Diarrhea and enteritis, commonly known as summer complaint, cause a great mortality among children in the United States. It is doubtful whether the average

person begins to realize the full extent of the ravages of this disease, and indeed of the mortality rate among young children. The Census Bureau shows that in 1908 nearly one-fifth of the deaths in the registration area of the United States, comprising about one-half of the population of the country as a whole, were of children under one year, and that the deaths of children under five years comprise more than one-quarter of the whole number of deaths. Ratios are not as convincing or as strong as actual figures, so that we may say in other words that the deaths in the registration area in 1908 amounted to 691,574; those of children under one year to 136,452, and of those under five years 189,865. It is a recognized fact that the general death rate of the country is largely dependent on its infant mortality.

The number of deaths among children becomes even more striking when we consider that in 1908, according to the census, 197.3 out of every 1,000 under one year died, while 274.5 out of every 1,000 under five years died. It is clearly shown that summer complaint is the most important cause of infant mortality. Irving Fisher, in his estimate of lives that could be saved, states that sixty out of every one hundred dying from this disease could have been saved. The actual number of deaths from summer complaint in 1908 was 52,213, of which 44,521 were under two years.

Of course there is no way of showing in what proportion of these cases of summer complaint the house fly was instrumental, but under conditions that exist

practically everywhere in midsummer, both as to the swarms of flies and the lax care of excreta among small children, it is impossible to avoid the conclusion that flies bear a very important relation to the number of cases and therefore to the number of deaths.

Nuttall and Jepson have abstracted a number of published papers on this subject, with the following results:

"The relation of flies to the spread of summer diarrhea has aroused special interest of recent years. Fraser (1902), referring to epidemic diarrhea in Portsmouth, states that 'on visiting the houses in question I find that in all, almost without exception, the occupants have suffered from a perfect plague of flies. They told me every article of food is covered at once with flies. * * * I repeat that to this, and this alone, I attribute the diarrhea in the Goldsmith Avenue district.'

"Nash (1903, p. 128) pointed out that there were twenty-three cases of the disease in Southend-on-Sea in 1901, whilst there were none in the summer of 1902. *M. domestica* was completely absent in the wet summer of 1902, but appeared in September of the same year; coincident therewith there occurred thirteen cases of infantile diarrhea. Nash (1904) considers that *M. domestica* is the chief carrier of diarrhea-causing bacteria.

"Newsholme (1903, p. 21) has expressed the opinion that food in the houses of the poor can scarcely escape fecal infection. 'The sugar used in sweetening milk is often black with flies, which may have come

from a neighboring dust-bin or manure heap, or from the liquid stools of a diarrheal patient in a neighboring house. Flies have to be picked out of the half-empty can of condensed milk before its remaining contents can be used for the next meal.' Newsholme considers the greater prevalence of diarrhea among infants fed on Nestlé's milk as due to the fact that flies are more attracted to it than to ordinary cow's milk because of its sweetness.

"Copeman (1906, p. 18), in a report to the Local Government Board dealing with epidemic prevalence of infantile diarrhea at Wigan, says: 'At the Miry Lane Depôt there is always stored (awaiting removal by farmers) an enormous amount of night-soil mixed with ashes which, in hot weather especially, is not only exceedingly offensive, but is beset by myriads of house flies. As the result of personal enquiry at the various houses in the neighborhood in which, during the year 1905, deaths from diarrhea had occurred, I learnt that considerable nuisance from the foul odors was apt to be experienced during the prevalence of hot weather, especially with the wind in the south or southwest, *i. e.*, blowing from the Depôt to the special area, so much so on occasions as to render it necessary to shut all the windows, while the inhabitants of houses nearest the Corporation Depôt stated that at certain times of the year their rooms were apt to be invaded by a veritable plague of flies, which swarmed over everything of an edible nature on the premises. This being so, it would appear not improbable that these flies, some of which

have doubtless had opportunity of feeding on and becoming contaminated with excremental material of human origin, may have been a means of carrying infected material to certain foodstuffs, such, more particularly, as milk and sugar, and so, indirectly, of bringing about infection of the human subject.'

"Snell (1906), Medical Officer of Health, Coventry, is stated by Ainsworth (1909) to have shown that seventy per cent. of the 'cases of infantile diarrhea occurred in the northeast part of his district, close to a large collection of refuse where flies swarmed.'

"Sandilands (1906, p. 90) considers that there are 'good grounds for the supposition that in this disease, which in some respects is analogous to typhoid fever and cholera, flies may be carrying agents of the first importance.' He notes that the meteorological conditions which influence the prevalence of diarrhea 'exercise a precisely similar effect upon the prevalence of flies.

" 'The immunity of well-to-do infants may be explained partly by the distance that separates the sick from the healthy and partly by the small number of flies in their neighborhood. In poorer districts six or seven babies may occupy the tenements of one house with a common yard where the flies congregate and flit in and out of the open windows, themselves conveying infected excrement to the milk of healthy infants, or depositing the excrement in the dust-bin, whence it may again be conveyed into the house by other flies. Calm weather promotes diarrhea, and high

winds are unfavorable to the spread of diarrhea and to the active migration of flies alike. Loose soil and fissured rock, containing organic filth in its crevices, favor the spread of diarrhea and the breeding of flies, whilst solid rock is unfavorable to both.' (See also Newsholme, 1906, p. 145.)

"Hamer (1908), who has studied the relation of fly prevalence (*Musca, Homalomyia*) to diarrhea from an epidemiological point of view, appears to be somewhat sceptical as to flies being active agents in the spread of infection. He considers that the increase in flies and diarrhea may be due simply to a coincidence.

"Ainsworth (1909, p. 498) has studied the relation of infantile diarrhea to flies in Poona and Kirkee, India, and illustrates the relation by means of a yearly curve which is very striking as affording evidence that flies stand in causal relationship to diarrhea.

"All authorities agree that flies rest under strong suspicion of serving as disseminators of diarrheal infection."

Jackson (1907) gives the results of numerous observations upon the relation of flies to intestinal diseases (including infant diarrhea) and the relation of deaths from intestinal diseases in New York City to the activity and prevalence of the common house fly is indicated not only by repeated observations but also by an interesting plotting of the curve of abundance of flies in comparison with the plotted curve of the abundance of deaths from intestinal diseases, indicating that the greatest number of flies occurred in the

weeks ending July 27th and August 3d, and also that the deaths from intestinal diseases rose above the normal at the same time at which flies became prevalent, culminated at the same high point, and fell off with a slight lag at the time of the gradual falling off of the prevalence of the insects.

Tuberculosis

The typhoid fly also possesses importance as a disseminator of the bacilli of tuberculosis. We have seen on an earlier page the method by which the adult fly feeds upon sputa. They are attracted to all sputa and feed upon them with avidity. One of the writer's assistants (himself a tuberculous patient) more than ten years ago wrote him from a Colorado resort telling of the lax care of the sputa of the consumptives, and stating that he had seen numbers of patients sitting upon a veranda and occasionally expectorating over the railing upon the ground where numerous flies had congregated and were feeding. The significant part of the letter, however, was the statement that the open windows of the kitchen were not many feet away from this particular portion of the veranda.

It is not difficult to understand the danger of the transfer of the causative organisms of the diseases of the alimentary tract by flies, but in regard to tuberculosis of the lungs, it should be stated that the observations of Nicolas and Descas (quoted by Cobb) indicated that fasting dogs fed with bouillon containing quantities of bacilli were shortly after examined and

smears were taken from the thoracic duct which indicated tubercle bacilli, thus showing how easily these bacilli can enter the general circulation.

Dr. Frederick T. Lord (1904), after a series of long and careful laboratory investigations, reached the following conclusions:

"1. Flies may ingest tubercular sputum and excrete tubercle bacilli, the virulence of which may last for at least fifteen days.

"2. The danger of human infection from tubercular fly-specks is by the ingestion of the specks on food. Spontaneous liberation of tubercle bacilli from fly-specks is unlikely. If mechanically disturbed, infection of the surrounding air may occur.

"As a corollary to these conclusions, it is suggested that—

"3. Tubercular material (sputum, pus from discharging sinuses, fecal matter from patients with intestinal tuberculosis, etc.) should be carefully protected from flies, lest they act as disseminators of the tubercle bacilli.

"4. During the fly season greater attention should be paid to the screening of rooms and hospital wards containing patients with tuberculosis and laboratories where tubercular material is examined.

"5. As these precautions would not eliminate fly infection by patients at large, foodstuffs should be protected from flies which may already have ingester tubercular material."

According to Nuttall and Jepson, the first investi-

gators to study the house fly in relation to the possible dissemination of tubercle bacillus were Spillman and Haushalter in 1887. They found tubercle bacilli in the intestinal contents of flies and in their dejections as well, the flies having fed upon tubercular sputum. They also show that Hofmann, in a paper published in 1888 on the spread of tuberculosis through house flies, reported certain observations under natural conditions. He examined flies captured in the room of a tuberculous patient and found bacilli in four out of six flies examined, as well as in the fly-specks scraped from the walls, door and furniture of the room. Similar observations are reported to have been made by Hayward (1904), Buchanan (1907) and Cobb (1905).

Much stress is now being laid upon the alimentary transmission of tuberculosis, and in view of the facts just stated it can hardly be denied that the house fly is a serious danger in the carriage of the "white plague."

Anthrax

Anthrax is an infectious and usually fatal bacterial disease of cattle, sheep, and other animals, producing ulcerations. It occasionally occurs in man, and is usually known by the name "malignant pustule." It has been shown by many authors that the bacillus of anthrax is carried by several species of flies, and Celli of Rome, as early as 1888, found that anthrax bacilli pass, unimpaired in virulence, through the alimentary tract of flies. Other observers have accomplished the transfer of anthrax by means of flies from experimental

animals to sterilized culture plates. It seems perfectly demonstrated that flies pick up anthrax bacilli when they walk about and when they feed upon infected material. It has not, however, been shown how long they may carry the bacillus, and it is not known whether its virulence is reduced by passage through their bodies. Nuttall suggested as early as 1899 that it appears probable that non-biting flies, like the house fly, may, when infected, spread anthrax by depositing the bacilli upon wounds or food.

It may be remarked incidentally that biting flies, such as the stable fly (*Stomoxys calcitrans*) or any of the gad-flies, biting an animal affected by the disease, might naturally be supposed to carry the *Bacillus anthracis* into the circulation of a human being by a puncture after a short period, and cases have been reported where malignant pustule apparently followed the bite of some fly. Efforts to prove this by experiment with biting flies and guinea-pigs, however, have not been successful. Nuttall in 1899 concluded that while it is conceivable that infection may occur in this way, it is probable that it is the exception and not the rule.

YAWS (*Frambœsia tropica*)

Yaws is a tropical disease, contagious and innoculable, characterized by the appearance of papules which develop into a fungus-like, incrusted, and excessively disagreeable eruption. It is widely distributed throughout the greater part of the tropical world, being very common in tropical Africa, especially on the west coast,

in many of the West Indian Islands, in Ceylon, Java, in Fiji, and Samoa, and other Pacific islands. It occurs in China, but is rare there. It is highly contagious, but simple contact of the skin is not sufficient—an abraded surface is necessary. Sir Patrick Manson says that probably the virus is often conveyed by insect bites or by insects acting as go-betweens and carrying it from a yaw sore to an ordinary ulcer; thus the disease often commences in a pre-existing ulcer. It is neither hereditary nor congenital.

Prof. E. W. Gudger, of the State Normal College at Greensboro, N. C., has called attention to a very early idea as to the carriage of yaws by flies, on pages 385 to 386 of Dr. Edward Bancroft's "An Essay on the Natural History of Guiana in South America," published in London in 1769. Doctor Bancroft writes, "The yaws are spongy, fungous, yellowish, circular protuberances, not rising very high, but of different magnitudes, usually between one and three inches circumference. These infest the whole surface of the body and are commonly so contiguous that the end of the finger cannot be inserted between them, and a small quantity of yellowish pus is usually seen adhering to their surface, which is commonly covered with flies through the indolence of the negroes. * * * It is usually believed that this disorder is communicated by the flies which have been feasting on the diseased object to those persons who have sores or scratches which are uncovered; and from many observations I think this is not improbable, as none ever receive this dis-

order whose skins are whole; for which reason the whites are rarely infected; but the backs of negroes, being often raw by whipping, and suffered to remain naked, they scarce ever escape."

Nuttall and Jepson state that Wilson (1868) says that the belief prevails in the West Indies that this disease is carried by flies. They also show that Hirsch (1896) reports two cases in which he thinks the disease was conveyed by flies. They also quote Cadet to the effect that lesions of the skin are necessary for infection, and that this may occur through direct contact with infected clothes or flies, the latter transporting the virus on their feet, which are soiled with diseased secretions.

The causative organism of yaws is supposed to be an extremely delicate spirochæte very much like that of syphilis. Castellani (1907) reports experimental investigations showing that with monkeys the disease can be conveyed by inoculation, showing also that yaws and syphilis are different diseases. The causative organisms of the two diseases appear to be distinct, that of yaws being called *Spirochæta pertenuis*. He makes the statement that there can be no doubt of the conveyance of the disease by direct contact from person to person, and that under certain conditions it may be conveyed by flies and possibly by other insects.

OPHTHALMIA

A number of years ago, while studying the habits of certain minute flies of the genus Hippelates, which

are commonly seen flying about the eyes of domestic animals, the writer was informed by the late Henry G. Hubbard that he believed these little flies to be responsible for the transfer of the pink-eye among the school children of Florida. He had known this disease to run rapidly through a school and had observed that the little Hippelates flies were always present and were much attracted to the inflamed eyelids.

When this observation of Hubbard's was mentioned to Dr. Lucien Howe of Buffalo, Doctor Howe informed the writer that in his opinion the ophthalmia of the Egyptians is also transferred by flies, and presumably by the house fly, and referred the writer to a paper which he had read before the Seventh International Congress of Ophthalmology at Wiesbaden in 1888. He referred to the extraordinary prevalence of purulent ophthalmia among the natives up and down the River Nile and to the extraordinary abundance of the flies in that country. He spoke of the dirty habits of the natives and of their remarkable indifference to the visits of flies, not only children, but adults allowing flies to settle in swarms about their eyes sucking the secretions and never making any attempt to drive them away. Doctor Howe called attention to the fact that the number of cases of this eye disease always increases when the flies are present in the greatest numbers and that the eye trouble is most prevalent in the place where the flies are most numerous. In the desert where flies are absent, eyes as a rule are unaffected. He made an examination of the flies captured upon diseased eyes,

and found on their feet bacteria which were similar to those found in the conjunctival secretion.

At the time when Doctor Howe told the writer of this paper, the latter was so filled with the idea that horse manure was far and away the most abundant producer of house flies that, inasmuch as there are comparatively few horses in the Nile Valley, he was inclined to suspect that the fly concerned in the carriage of this disease as pointed out by Doctor Howe might be some other species breeding by preference in camel dung or perhaps in some other substance. He therefore sent to Egypt and secured specimens of the flies commonly swarming about the eyes of ophthalmic patients, and on their receipt in Washington they were readily determined as *Musca domestica* by Mr. D. W. Coquillett of the Bureau of Entomology.

Nuttall and Jepson show that Budd, as early as 1862, considered that it was fully proven that flies served as the carriers of Egyptian ophthalmia, and Laveran, in 1880, writing of Biskra, says the same. These writers also point out that Braun (1882), Demetriades (1894) and German (1896) agree that gonorrheal and other infections of the eye may be carried by flies. They state that Welander (1896) observed an interesting case where an old bedridden woman in a hospital became infected. It seems that her bed was alongside that of another patient who had blennorrhea, but that a screen which did not reach to the ceiling separated the beds. Thus all means of infection except through the agency of flies was apparently absent. The inves-

tigator found that flies bore living gonococci upon their feet three hours after they had been soiled with secretion, since they infected sterilized plates with which they came in contact.

Nuttall and Jepson conclude their consideration of ophthalmia with the following statement: "The evidence regarding the spread of Egyptian ophthalmia by flies appears to be conclusive, and the possibility of gonorrheal secretions being conveyed by flies cannot be denied."

Diphtheria

Nuttall and Jepson have been able to find only one reference to the dissemination of *Bacillus diphtheriæ* by flies. They state that Dickinson (1907) cites Smith (1898) as having tried the oft-repeated type of experiment of allowing house flies to walk over infected material and then over sterile media. A positive result was obtained as a matter of course. The authors state that there is no evidence that under natural conditions flies have anything to do with the spread of diphtheria, but indicate that it is of course conceivable that they may convey the infection under suitable conditions.

Small-pox

The only published account of the possible relation of flies to small-pox cited by Nuttall and Jepson is taken by them from a paper by Hervieux, read June 5, 1904, to the Academy of Medicine at Paris, in which he states that Laforgue at a locality in the province of Constantine observed that during an epidemic of small-

pox the children who were attacked all lived in the southwest of the village, the northern part of the village remaining free from the disease. This distribution was thought to be due to the direction of the prevailing winds, and observations were made to the effect that flies and mosquitoes were distributed with the wind. Laforgue himself believed that flies played an important part in the spread of the virus of small-pox.

Plague

So much is now known concerning the specific origin of bubonic plague and concerning its carriage by the several species of fleas which occur upon rats, which are also subject to the same disease, that house flies cannot be claimed to be of importance in this connection; but old writers have noted the occurrence of flies in large numbers in plague years, and one of them at least considered that house flies carried the disease, simply from the fact that they visited food after they had abandoned plague patients.

Nuttall and Jepson call attention to the fact that Yersin, in writing upon bubonic plague at Hong-Kong in 1894, stated that he saw many dead flies lying around in his laboratory when he was conducting autopsies on animals killed by the plague. He demonstrated by inoculation into animals that a dead fly contained virulent plague bacilli.

Nuttall himself had in 1897 already experimented with the house fly, feeding it upon organs of animals dead by the plague. He found that the flies might

survive for eight days after feeding on infected organs and that they still harbored virulent bacilli forty-eight hours and more after they were transferred to clean vessels. At high temperatures the infected flies died more rapidly than controlled flies which were fed on the organs of healthy animals, from which he concluded that the plague bacillus may be fatal to house flies under suitable conditions of temperature. This possibly accounted for the dead flies noted by Yersin in his Hong-Kong laboratory. Nuttall also points out that a French observer, Matignon, observed in 1898 that flies died in large numbers in Mongolia during plague times.

Tropical Sore

This disease is referred to by Nuttall and Jepson under this name and also under the name "Bouton de Biskra." They state that it is asserted by Laveran and Seriziat (1880) that flies convey this trouble. In other localities, the natives declare that the disease is caused by the bite of certain insects. It is said that Seriziat asserts that a lesion of the skin is always necessary for an infection to take place, and that it unquestionably results at times as a consequence of mosquito bite. Laveran in his observations at Biskra stated that from September to October the slightest wound tends to be transformed into the bouton. He has seen it graft itself upon pustules of acne, upon vaccine pustules, and upon wounds following burns or blisters. He does not doubt that it is carried by flies on their feet and on their beaks.

Parasitic Worms

Nuttall and Jepson refer to the experiments made by Grassi in 1883. When he broke up segments of the human tapeworm in water after these had been preserved some months in alcohol, he saw that the flies came and sucked up the eggs with the water and that the eggs were passed unaltered through the bodies of the flies. He had the same results with the eggs of Oxyuris, one of the so-called "thread-worms" or "pin-worms."

While experimenting with the unsegmented eggs of still another of the genus Trichocephalus (one of the so-called "whip worms," having a long, slender neck like a whip lash), which were placed upon a table, he saw flies feed on them and later found the eggs in the fly-specks which had been deposited in the kitchen on the floor beneath, ten yards away from the place where the insects had been fed. He caught some flies whose intestines were full of the eggs.

Nuttall also records an observation of Dr. C. W. Stiles, of the Public Health and Marine-Hospital Service, which had been sent to him in a personal letter, showing that Stiles had placed fly larvæ with the female of *Ascaris lumbricoides* (the most abundant of the "round worms," which inhabit the small intestine, especially with children), which they devoured together with her eggs. He afterwards found that the larvæ and the adult flies contained the eggs of the Ascaris. The experiment was made in very hot weather. The

Ascaris eggs developed rapidly and were found in different stages of development in the insects, thus proving that the flies may serve as disseminators of the parasite. "Provided that the eggs attained the proper stage of development, the fly, acting simply as a carrier, might convey the parasite to man by falling into, or depositing its excreta on, the food."

IV

REMEDIES AND PREVENTIVE MEASURES

TO avoid only the *danger* from flies, you must destroy or protect from them all substances containing disease germs. This is done in large part, so far as intestinal diseases are concerned, by the water-closet system in cities, and it may be done by sanitary privies in villages and country houses and in mining and construction camps; and also by properly cared-for trenches or latrines at temporary army posts. To avoid danger from flies in the case of lung troubles, the proper care of the sputa is essential.

To avoid the *nuisance* of flies it becomes necessary practically to get rid of them, and in doing this of course we get rid of the danger at the same time. It has always seemed to the writer that the truest and simplest way of attacking the fly problem is to prevent them from breeding, by the treatment or abolition of all places in which they can breed. To permit them to breed undisturbed and in countless numbers, and to devote all our energy to the problem of keeping them out of our dwellings or to destroying them after they have once entered in spite of all obstacles, seems the wrong way to go about it. To the individual who has control of the grounds for some distance about his abiding place, the former method is undoubtedly the

best, and it would also undoubtedly be the best in any event if, by co-operation of the residents or by the active efforts of a central body, like the boards of health in cities, it were possible to do thorough work with the breeding places.

In cities and in towns, however, where the requisite co-operation cannot be obtained, and where boards of health are still indifferent, careful consideration must be given to the second method, namely, keeping flies out or killing them after they enter.

A third method has been proposed and is enthusiastically advocated by Professor Hodge, of Clark University, Worcester, which is based upon the supposed time elapsing between the issuance of the adult fly and the period when it lays its first eggs. Professor Hodge, as will be shown later, thinks that it is quite possible to trap these sexually immature adults during this period, which now seems comparatively long, and thus to prevent not only their entrance into houses and shops and markets, but to destroy so many of them that the comparatively few which reach sexual maturity will not be able to lay their eggs in sufficient numbers to make the next generation a nuisance. In other words, he thinks that it will be possible to bring about such a condition that the manure pile may be left undisturbed until it is needed to fertilize the land.

Whether this can be done or not—and Professor Hodge's argument seems reasonable—will again depend upon co-operation in communities, although individual effort in isolated places may bring it about.

Success will also to a great degree depend upon the applicability of Doctor Hewitt's isolated observations upon the period between issuance and sexual maturity to other seasons and to other parts of the world.

Screening

Three years ago I made an attempt to estimate the amount of money spent annually in screening houses in the United States. As close an estimate as could conscientiously be made seemed to indicate that more than $10,000,000 are spent every year for this kind of protection against flies and mosquitoes. In fly-ridden localities the expense is undoubtedly justified, since the majority of the flies are kept out by careful screening. No system of screening, however, seems to be so perfect as to keep them all out. They get in, one way or another, in spite of care; even where double doors are used they eventually gain entrance. In the summer time, in country houses having large open fireplaces disused during warm weather, flies undoubtedly come down the chimney, and it is necessary under those conditions to arrange a wire screen before the open fireplace in such a way that it can easily be removed on a cold day.

The whole expense of screening, however, should be an unnecessary one, just as efforts to destroy flies in houses should be unnecessary. Their breeding should be stopped to such an extent that all these things would be useless.

Fly Traps and Fly Poisons

In the effort to destroy the flies which have gained access to houses many devices have been invented, and many of them have been patented. Nearly all of the traps which are on the market are reasonably effective, and it will be unfair to mention any one or two or three where so many are good. They are all cheap and it is a simple matter for one to test them one after another until the most satisfactory one is found. Very effective traps are made of sticky fly paper—flat sheets to be laid on tables, bookcases, or in other places.

A recent idea, gained from the observation that flies in rooms where there is no food seem frequently to rest by preference upon vertically hanging cords of window curtains, on the supports of chandeliers, and objects of that general character, has resulted in several arrangements by which strips of sticky fly paper are suspended in this way, and this has given in many cases satisfactory results. One of the writer's friends, in experimenting with one of these devices, examined the room carefully and noted eleven flies. After the apparatus was hung he found rather to his surprise that he had caught thirteen flies! He became rather enthusiastic over the merits of the device. These sticky fly papers are not poisoned, and depend for their efficacy upon the catching of the flies.

Poisoned fly papers were at one time very much in use and are still in some localities. The old dispensatories give an account of a harmless fly poison prepared

in the following way: "Macerate during twenty-four hours 1,000 parts of quassia wood with 5,000 parts of water, then boil for half an hour; set aside for twenty-four hours and press. Mix the liquid with 150 parts of molasses, and evaporate to 200 parts. A weaker decoction of the quassia does not kill the flies. From this the fly water or fly plate is prepared as follows: Mix when needed and dispense without filtering, 200 parts of syrup of quassia, fifty parts of alcohol and 750 parts of water. It is used by moistening with the mixture a cloth or filtering paper on a plate."

The native ore of speiss cobalt is found in commerce under the name of flystone, and was at one time extensively used for poisoning flies by roughly grinding it and putting a small quantity in a saucer with sweetened water.

It is possible to poison flies rather satisfactorily by putting a lump of sugar in a saucer partly filled with water and adding white arsenic. This, of course, is dangerous where there are children or house dogs or cats about.

Of the unpatented fly traps, a device was recommended by Mr. P. J. Parrott, Entomologist of the Kansas Experiment Station, in Bulletin 99 of the Station (October, 1900), as follows:

"The department of entomology, after experimenting upon various mechanical devices for catching flies, has contrived a trap and recommended it for trial on account of its effectiveness and cheapness. Anybody with an average amount of mechanical ingenuity can

make and attach the trap, with a cost of but a few cents. It is made as follows:

"Take a flat strip of tin two and one-fourth inches wide and one and one-half inches longer than the distance between the side rail or stile and middle rail of the sash, as from *c* to *d,* Fig 3, which in this case measured twenty-one inches. For this window, the strip must be twenty-two and one-half inches in length. With the tin lying on the flat surface, bend the tin along the lines *ab* and *cd,* Fig. 1, which are three-quarters of an inch from their respective sides, so that the space *abdc* forms the bottom of a box and the lateral parts the sides. To close the ends, cut small incisions three-quarters of an inch deep at the points *a, b, c,* and *d,* as *ay* and *cx,* Fig. 1. Bend the flaps thus made at right angles to their respective parts. We then have a box twenty-one inches long, three-quarters of an inch wide, and three-quarters of an inch deep, as at Fig. 2.

"To make the box water-tight, solder the joints, or if solder is not handy try moistened plaster of Paris. When properly made, the box should fit snugly between the middle and side rail or style. The corners should be square and the edges straight, so as to leave no passageways between the box and the glass. The box should rest on top of the bottom rail, and can be held in place by two or three tacks or pins thrust into the rail from the back side. When the pane is very large it is well to attach another trap half way between the top and the bottom.

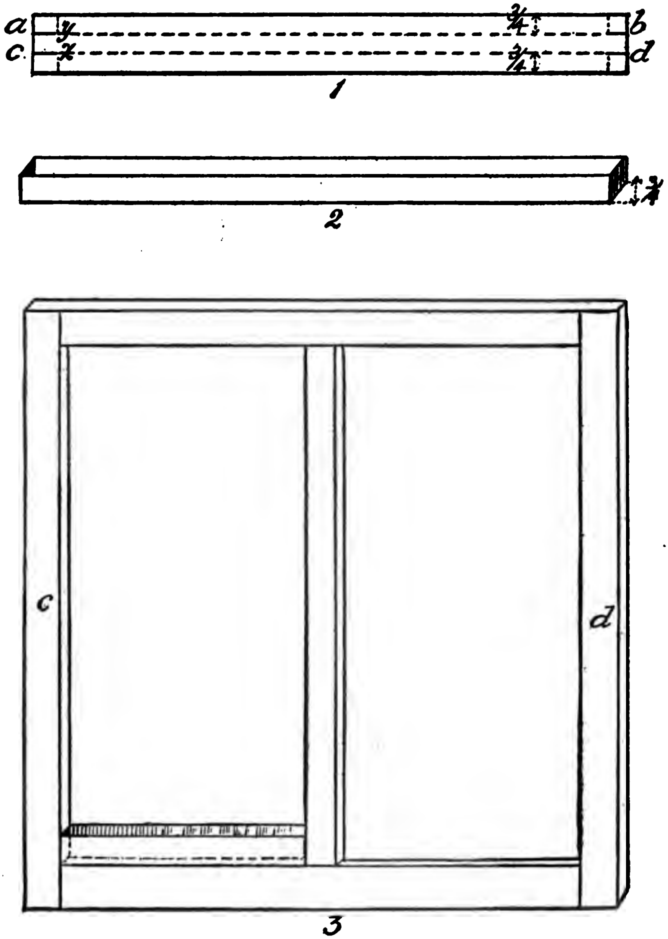

Fig. 19.—Details of window trap. (Redrawn from Parrott.)

"After the traps have been attached, some substance should be put into them that will either kill the insect upon falling into it, or on account of its sticky nature will hold the insect so that it cannot escape. For the first, kerosene, kerosene emulsion, soapsuds and pyrethrum are the best; and for the second, molasses, or a mixture of castor-oil and resin. For general use, the soapsuds are to be recommended. *When using the liquids, fill the traps two-thirds full.*

"There should be one trap for every pane of glass of at least one window in the house. For instance, when the sash contains two panes of glass, as in the cut, there should be two traps, one at the base of each pane. When the sash contains four panes, there should be four traps, two on the bottom rail and two on the cross-bars or munting. It is not necessary to apply traps to all the windows. Attach traps to one or two windows in the sunny part of the house, and pull down the blinds of the remaining windows. The flies will seek the lighted rooms, and especially the windows.

"When the traps are full of flies, remove them from their fastenings, empty out their contents, and fill them with fresh material.

"A temporary trap can be made of flexible cardboard, following the same directions as for those made of tin. Use glue or pins to fasten the ends. To render the trap water-proof, paint the inside with melted paraffin. This will hold any of the above remedies except the pure kerosene."

A correspondent, Dr. D. S. Hager, has made a suc-

cessful fly trap which cost for material about fifteen cents, and writes that any bright boy can make one of them in an hour or two. He took two pieces of board one inch thick and about a foot square; tacked them together, sawed them round, and in the center sawed a hole eight inches in diameter. He then separated the boards, and into one he fitted a funnel-shaped piece of wire screen about ten inches high, which was fastened to the board with tacks driven on the inside of the round hole and fastened together funnel-shaped with a strand of the wire selvage. A small hole, large enough to admit a lead pencil, was left at the apex of the funnel for the flies to creep through. He then tacked a piece of wire netting, eighteen inches wide, to the outside circumference of each of the round boards, with the funnel-shaped wire on the inside. The outside of the wire was again fastened with the selvage of the wire. On the top he tacked a piece of wire screen in such a way that he could readily remove it to empty out the flies. He then nailed lengthwise on the outside of the trap a few laths to make it more firm. He then made feet by screwing into the bottom piece containing the funnel four wire coat-hangers about five inches high.

He placed these traps (he made two at the same time) one on each side of the front porch, and under each he placed a plate with some sugar on it and a cup of sweetened water in the plate. Flies were attracted by the sugar and sweetened water, and as they flew over the bait they crawled through the hole in the fun-

nel up into the trap. The traps caught many each day, and were soon filled with a buzzing mass. He suggests that a trap of this kind should be placed near the door of a house, as flies will congregate at the top of the screen door and enter the house when the door is opened.

He caught quarts of flies, and at first killed them by pouring scalding water over them, but this had a detrimental effect upon the wood and wire of the trap, so he killed them by fumigating with sulphur, setting a large paper packing box over all, destroying them in this way in about two and a half minutes.

Many different kinds of fly traps are used in different parts of the world. We read, for example, in the Journal of the Department of Agriculture of Western Australia that flies may be effectually destroyed by putting a half spoonful of black pepper in powder on a teaspoonful of brown sugar and one teaspoonful of cream. Mix all together and place in a room where flies are troublesome and it is said they will soon disappear.

Dr. Paul Freer of Manila tells the writer that in the Japanese hospitals they take a whole potato and stick it full of toothpicks, put fly paste on the toothpicks, and hang the potatoes from the ceiling over the patient's bed on a cord. The flies all gather on the potato, and when it is full they throw the potato away and make a new trap. The toothpicks are placed about one-fourth of an inch apart, and the potato presents the appearance of a porcupine.

Formalin

Ten years or more ago, when formaldehyd gas was found to be a good germicide, experiments were made with it against different insects without success; but the evaporation of formalin has continued to be of use in sick rooms. Quite by accident it was discovered by different people, apparently in different parts of the world, that a formalin solution is a good mixture with which to poison flies in the house. So far as we know, the first person in this country to ascertain this was Mr. C. H. Popenoe, who at that time was at the Kansas Agricultural College. In the summer of 1903, during the prevalence of an unusual number of house flies, while mixing a solution of formaldehyd for the preservation of insects (four per cent. formaldehyd, or dilution to ten per cent. commercial), a quantity of the mixture was left in a mixing dish on the table. Several flies were noticed to alight and drink of the mixture, quickly succumbing to its influence. A quantity was therefore placed on a deep plate and set upon the table. This remained on the table all the afternoon, and in the evening was surrounded by many dead flies. The room was practically cleared of the pests. The dish of formaldehyd was used many times during that summer and in subsequent years with excellent effect as a fly poison. The flies seemed not to object to the presence of the formalin, drinking the water with avidity and dying close to the plate or saucer, where they were readily swept up.

Some one else in England and possibly some one else in France seem to have discovered the same fact in very much the same way. According to Galli-Valerio (1910), a ten-per-cent. formalin solution has been recommended by certain European writers. Trillat and Legendre, for example, advised ten-per-cent. formalin solution with the addition of twenty per cent. milk. The Fly Committee of the Merchants' Association of New York, on the basis of an item in the London Lancet, have advised the use of formaldehyd. A number of correspondents, however, have written that they found it unavailing. Dr. Daniel S. Hager, of Chicago, for example, used formaldehyd in water and also formaldehyd in milk; a few flies were found about the receptacle, but the results as compared with the results of fly paper were insignificant.

Hodge (1911) states that he has been successful in the use of a teaspoonful of formalin to a teacupful of water. He fills a big bottle with the mixture, inverts it in a saucer and mounts the whole in a most likely place. Sweetening it or mixing it with milk or other foods to make it more attractive will, he says, result in the destruction of flies.

Herms, of the University of California (1910), states that formaldehyd has given thorough satisfaction as a substitute for poisons. He points out that it is non-poisonous to man, and may therefore be used with impunity around food. It is a powerful germicide and does not injure delicate fabrics. He states that formalin as purchased in the drug store is in about forty-per-

cent. solution and should be diluted with water down to five per cent. or eight per cent.; in other words, add five to six times as much water. This solution, he says, should be sweetened with sugar or made attractive by adding milk.

He advises partly filling a shallow vessel, such as an individual butter dish, and placing it upon the table or in the show window. He states that the flies drink this material and die not far from the containers. In the dining-room where there is water, milk, or other liquid food, flies are said not to be so greatly attracted to the formalin, but where this is made the only source of drink for the insects the results are said to be remarkable. Herms recommends that all other liquids except the formaldehyd dishes in a given room should be removed or securely covered in the evening, so that the flies have only the formaldehyd to drink early in the morning when they begin to fly.

Some careful experiments were tried during early February, 1911, at New Orleans, La., at the request of the writer, by Mr. T. C. Barber. Mr. Barber's notes indicate success. The mixture used was formaldehyd (forty-five per cent.), two ounces; sugar, two ounces; water, ten ounces. On February 14th he placed some of this solution in an open saucer in the show window of a grocery store, where a few flies were present. After being left about one hour, seven dead flies were found in the window, which had previously been thoroughly cleaned. He then placed the material in two

saucers with a piece of bread in each. The bread soaked up the solution until it was saturated, and was left over night. The next morning a large number of dead flies were found in the neighborhood of the saucers, and were removed. The next day many more dead flies were found, and very few could be found in the shop.

On February 15th, he placed some formalin mixture in a petri dish on one of the meat shelves of a private meat market. Flies were very abundant. He had no bread to put in, and so went down to a corner grocery about one square away to get some. He was absent ten minutes, and on returning found about one hundred dead flies on the table where the solution had been placed. The next day he examined the place in the morning, and found hundreds of dead flies lying around, and the numbers in the room were reduced very materially. The test was conducted under favorable conditions, and gave excellent results. Other experiments by Mr. Barber produced similar results.

Pyrethrum and Carbolic Acid

The fly-fighting committee of the American Civic Association recommend the burning of pyrethrum powder and also the dropping of twenty drops of carbolic acid upon a hot shovel, stating that the vapor kills the flies. The Secretary of the Association, Mr. Watrous, informs the writer that correspondents have complained that neither the pyrethrum nor the carbolic acid was in the least effective. I have never tried the

carbolic acid, but pyrethrum powder is certainly effective when at all pure.

Many of the so-called pyrethrum or Persian insect powders sold in the shops are impure. The powder itself is made from the ground flower-heads of two species of the genus pyrethrum, which are composite plants not unlike the common ox-eye daisy. It is a not uncommon practice for makers of these powders to grind the stems as well as the flower-heads, thus producing a dilution which greatly lessens the effect of the powder. The insecticidal element in this powder seems to be an oleo-resin, and therefore a freshly ground powder is more effective than an old one. In most of the pyrethrum powders to be found in the shops the heads have been imported from Europe and ground in this country.

There are, however, powders of a somewhat higher price made from pyrethrum flower-heads grown in California in the vicinity of Stockton. These appear to be the freshest and strongest, but they cost more. It has been the experience of the writer that these California powders are effective against house flies either when puffed into the air or when burned by puffing through a gas jet, or by making moistened cones put upon earthen dishes and ignited at the top.

Repellents

Flies do not seem to be repelled by odors to the same extent that mosquitoes are. Some old ideas in this direction, however, may be mentioned. It is stated

that the butchers of Geneva have from time immemorial prevented flies from approaching the meat which they expose for sale by the use of laurel oil. This oil—the odor of which, although a little strong, is not very offensive—is said to drive away flies, and they are said not to come near walls which have been rubbed with it. Furthermore, an item in the Journal of the Department of Agriculture of Western Australia states that flies may be kept out of stables by using sawdust which is saturated with carbolic acid diluted—one part of the acid to one hundred parts of the water. It is said that this sawdust scattered about stables keeps all flies away.

The idea prevails in some parts of the country that the hop vine grown over a country house keeps the flies away. Positive testimony to this effect has come to the writer from several correspondents, but he has not tested it and mentions it on hearsay evidence only. An American correspondent who lived in Dalmatia, for example, was troubled by flies, and was told by natives to grow hop vines over the side of the house towards which the flies appeared to come. She did so, and states that the fly invasion was stopped after the vines reached a certain height. There was, however, possibly some explanation of this aside from the hop plants.

Search for Breeding Places

In a general way the character of the breeding places of flies has been described in Chapter I, and the state-

ment is there made that they will breed in almost any fermenting organic material. They prefer horse manure, but will breed in human excreta, in cow dung, and the dung of pigs, fowls, and other animals, in fermenting spent hops, bran, in ash barrels containing more or less organic matter, and in everything of the sort. Search must therefore be made for every accumulation of refuse of this kind within a large radius. To gain the requisite conditions for fermentation, it is necessary as a rule for the substances in which flies will breed to accumulate until a considerable quantity is reached, at least such an amount as will be readily noticeable; so that the search for the breeding places of the bulk of the flies of a given neighborhood need not be a very close one.

The question arises, however: In how small an amount of breeding material will fly larvæ be found? Certain breeding materials will remain moist in small quantity longer than others; a single dropping from a cow is very liquid, but it hardens so rapidly on top and its exterior becomes so tough that the house fly seems to find difficulty in issuing from it, and perhaps that is one of the reasons why this substance is not a more prolific breeding place for this species than it is; though certain other flies, such as the horn fly of cattle, breed in cow dung in great numbers.

Horse dung is so mixed with the materials which have been eaten that it dries very quickly indeed all through the mass; so that a single dropping of a horse in a pasture under ordinary summer conditions will

dry so quickly from top to bottom that, although flies may and do lay their eggs on it, the larvæ are for the most part destroyed by the drying. When the weather is at all moist, however, these individual horse droppings will give out their supply of flies. Again, if the drying of the manure is delayed only until the larvæ have reached a certain size, they will still be able to transform. An experiment made by Hine in this direction is of interest as showing the vitality of larvæ under adverse conditions. Several glass jars were partly filled with thoroughly air-dried horse manure; then from a manure pile larvæ of different sizes were procured, sorted, and put into the jars; flies issued in every case, but those from the larvæ that were smallest when sorted out were not more than half normal size. This suggests that larvæ do not have to be very large before they are in position to contend with adverse conditions and produce adults even when the food supply is shut off, since it seems reasonably certain that larvæ will not feed upon perfectly dry substances.

As to human excreta, observations have shown that single droppings in the field or elsewhere will support a generation of flies perfectly. In Washington in the summer of 1900 this was proved on numerous occasions during June and July.

The possibility of fly breeding from spread manure is another important and very practical point. Hine's unpublished observations on this point are interesting. Cages covering twenty-five square feet of surface were

constructed, and horse manure infested with larvæ was spread at the rate of one quart to a square foot. Flies came out in abundance in these cages, although the weather was such that the manure and the soil beneath it were very dry during the time the observations were taken. After the flies from the larvæ that were in the manure at the time it was spread out all emerged, the cages were kept in place for several weeks, but another generation of flies did not appear, indicating that the careful spreading of manure in the fields in the summer does not cause the death of the pupæ and of the majority of the larvæ that are in it at the time the spreading is done, but it does, on the other hand, prevent the development of future generations in this same manure.

Thus it often happens that after a lawn has been heavily manured in early summer the occupants of the house will be pestered with flies for a time, but finding no available breeding places these disappear sooner or later. Another generation will not breed in the spread manure.

In the search for breeding places no accumulations of rubbish of any kind must be ignored. Even old rags and paper under proper moisture conditions will afford breeding places. All such substances should be removed or destroyed.

The Treatment of Horse Manure

Some experiments were tried by the writer in the summer of 1897, with the intention of showing

whether it would be possible to treat a manure pile in such a way as to stop the breeding of flies. Previous experience with the use of air-slaked lime on cow manure to prevent the breeding of the horn fly suggested the experimentation with different lime compounds. It was found to be perfectly impracticable to use air-slaked lime, land plaster, or gas lime with good results. Few or no larvæ were killed by a thorough mixture of the manure with any of these substances.

Chloride of lime, however, was found to be an excellent maggot-killer. Where one pound of chloride of lime was mixed with eight quarts of horse manure, ninety per cent. of the maggots were killed in less than twenty-four hours. At the rate of a quarter of a pound of chloride of lime to eight quarts of manure, however, the substance was not sufficiently strong. Chloride of lime, although cheap in Europe, costs at least three and one-half cents a pound in large quantities in this country, so that frequent treatment of a large manure pile with this substance would be out of the question in actual practice. Moreover, if the manure receptacle is in the stable where horses are kept, or in close proximity to it, the chlorine fumes arising from a pile thus treated would be an irritant to the eyes of the live stock.

After these experiments with lime, kerosene was used. It was found that eight quarts of fresh horse manure sprayed with one pint of kerosene which was afterwards washed down with one quart of water was thoroughly rid of living maggots—every individual

was killed by the treatment. This experiment and others of a similar nature on a small scale were satisfactory. Practical work during the summer of 1898, however, demonstrated that on a large scale this substance cannot be used to good effect. A large manure pile containing the accumulations of a week or ten days or two weeks and coming from a stable in which four horses were kept was sprinkled thoroughly with kerosene and an attempt was made to wash the kerosene down to a certain extent with water. The experiment was begun early in April and was carried on for some weeks. While undoubtedly hundreds of flies were destroyed in the course of this work, it was found by the end of May that it was far from perfect, since if used at an economical rate the kerosene could not be made to penetrate through the whole pile of manure. A considerable proportion of larvæ escaped injury from this treatment, which at the same time was found to be very laborious. It was a measure, in fact, which almost no one could be induced to adopt practically.

The actual experiments indicated the following facts:

Eight quarts of fresh horse manure alive with maggots were mixed August 5th with two quarts of air-slaked lime. August 7th no larvæ were dead, and on August 9th very many had hardened into puparia.

August 6th, eight quarts of horse manure were thoroughly mixed with two quarts of gypsum or land plaster. No larvæ were dead three days later.

August 7th, eight quarts of horse manure alive with larvæ were thoroughly mixed with two quarts of gas

lime and spread out in a large tin pan. Two days later most of the larvæ were found to have hardened into puparia, but none was killed.

September 4th, eight quarts of fresh horse manure containing larvæ were spread out in a tin pan and sprayed with one pint of kerosene washed down with one quart of water. September 7th, three days later, twenty per cent. of the larvæ were still living.

September 7th, eight quarts of fresh horse manure containing house fly larvæ were placed in a tin pan, sprayed with one pint of kerosene, washed down afterwards with one quart of water. The manure was then mixed and a little more water poured on. Twenty-four hours later every larva in the mass was dead.

October 15th, one pound of chloride of lime was mixed with eight quarts of well-infested horse manure, which was kept in a bucket. October 16th, ninety per cent. of the larvæ were dead, the remainder having burrowed into the large lumps of manure. October 18th, no living larvæ could be found.

October 21st, one-quarter of a pound of chloride of lime was mixed with eight quarts of fresh horse manure and kept in a bucket. This treatment was unsuccessful and only two larvæ were killed.

Herms also conducted certain experiments in this direction at the University of California. He found that the fly larvæ are extremely tenacious of life, and that insecticides which will kill them must be strong, in fact from two to five times as strong as those which are useful against other insects. He writes, "Chem-

icals used to destroy the larvæ in the manure pile may be roughly divided into two classes: (1) Contact poisons, and (2) stomach poisons. To the first class belong such preparations as the kerosenes (generally used in the form of emulsions) and the creosol preparations, also chloride of lime. To the second class belong the arsenicals, represented by arsenate of lead and Paris green. All of these insecticides are more or less effective when used in proper concentrations and in sufficient quantities, but none of them can be applied with any degree of safety to man or to the domesticated animals because of either their inflammable, poisonous, or corrosive nature."

Prof. S. A. Forbes, of Illinois, also caused a series of experiments of this sort to be carried on at the Illinois State Experiment Station at Urbana. The work was done under his direction by Mr. J. J. Davis. The notes have not been published, but have been kindly sent to the writer by Professor Forbes. In these experiments it was found that three pounds of hydrated high calcium lime of the Marblehead Lime Company, mixed with fifteen pounds of horse manure, killed ninety-four per cent. of the larvæ; two pounds mixed with twelve pounds of manure killed sixty-nine and one-tenth per cent. of the larvæ; four pounds with twelve pounds of manure killed sixty-one and three-tenths per cent. The diminished percentage in the last two experiments is accounted for by the fact that the larvæ were nearly full-grown.

An experiment with two pounds of iron sulphate

dissolved in a gallon of water and poured upon fifteen pounds of horse manure showed that 941 out of every 1,000 larvæ, or ninety-four and one-tenth per cent., were killed, while the same amount poured upon twelve pounds of horse manure killed ninety-five and seven-tenths per cent. of the larvæ. Other experiments with the same substance indicated in one case that two and one-half pounds of the iron sulphate to the gallon of water poured on twelve pounds of manure killed but seventy-one per cent. of the larvæ; in still another, two pounds of the sulphate and two gallons of water poured upon fifteen pounds of manure killed eighty-three and five-tenths per cent., while one gallon of the same solution to eleven pounds of manure killed none. Experimenting with dry powdered iron sulphate mixed with horse manure at the rate of two and one-half pounds to the fifteen, he found eighty-seven and two-tenths per cent. of the larvæ destroyed. At the rate of two and three-eighths pounds to twelve, eighty-six per cent. were killed. At two pounds to fifteen, forty-four and three-tenths per cent. were destroyed. At the rate of one and one-half pounds to twelve, sixty-nine and seven-tenths per cent. were killed.

The conclusions drawn from these experiments were that the breeding of the house fly in manure can be controlled by the application of a solution of iron sulphate—two pounds in a gallon of water for each horse per day—or by the use of two and one-half pounds of dry sulphate per horse per day. It was calculated that the average city horse produces about fifteen pounds

of manure daily; the larger work horses produce twenty to thirty pounds per day, but, as they are out of the stables most of the time, the actual amount to be treated would be much less. The average cost of the treatment would be one and one-half to two cents per horse per day. It is stated also that iron sulphate has the advantage that it completely deodorizes the manure.

Experiments were also made under Forbes's direction with borax, with a mixture of sodium arsenate and borax, with a lime-sulphur solution, with salt, and with carbon bisulphid. It was found that a solution of thirteen ounces of borax to three-fourths of a gallon of water sprayed over fifteen pounds of infested manure destroyed over ninety-nine per cent. of the maggots. A gallon of water containing eleven and one-half ounces of borax and seven ounces of sodium arsenate applied to twelve pounds of manure killed all of the larvæ. A pint of lime-sulphur solution in a gallon of water applied to twelve pounds of manure killed eighty-six and four-tenths per cent. of the larvæ, while a pound and a half of salt to one gallon of water applied to twelve pounds of manure killed eighty-eight and eight-tenths per cent.

A fluid ounce of bisulphid of carbon evaporated in a closed box fourteen inches by fourteen inches by nine inches, containing twelve pounds of manure, destroyed ninety-nine per cent. of the larvæ.

Whenever the subject of treating manure, in order to kill the maggots which are living in it, is mentioned, the question arises: What effect will the treatment have

upon the manure itself? Will it destroy its qualities and render it less valuable as a fertilizer? The ideal treatment would be to kill the fly larvæ and make the manure more valuable, if that were possible. Finding that the use of iron sulphate seemed practical, as just pointed out, Forbes consulted a competent chemist, and received a reply from which he quotes as follows in a letter recently received by the writer:

"A great deal of work has been done by German and French investigators in using sulphate of iron as a fertilizer. On going over this work carefully, we cannot find that sulphate of iron has ever proven injurious to the soil. On the contrary, its use gave very beneficial results in practically all cases. When sulphate of iron is added to manure it will rarely, if ever, reach the soil; this for the reason that it will be converted either into ammonium iron compounds or decomposed into its elements. We have used as high as one hundred pounds of sulphate of iron to one square rod without rendering the ground sterile."

Professor Forbes goes on to state that his correspondent added that sulphate of iron is now being used in Florida by some of the most progressive orange growers and that very many carloads of it were shipped into that State during the summer of 1910. Further, that the orange growers of California are also buying it in large quantities. His correspondent concludes by stating that the small amount of sulphate of iron necessary for the extermination of flies will not have a deleterious effect upon the soil.

Dr. H. W. Wiley, the Chief Chemist of the U. S. Department of Agriculture, was asked for an opinion regarding the effect upon the manurial value of manure treated by the substances experimented with under Professor Forbes's direction. He replied, "The materials which you mention would affect the agricultural value of manure in three ways: Alkalies would drive off ammonia, and if in not too large quantities, would hasten fermentation. Lime salts and iron sulphate would tend to render the phosphates unavailable. All of these materials mentioned, with the possible exception of salt, would, if used in sufficient quantity, kill the bacteria of the manure and thus reduce its value, as undoubtedly the value of stable manure is largely due to the great number of very active bacteria which it contains. I cannot inform you in what quantities these various materials would be required to seriously reduce the bacterial content of manure, but it would seem that, if used in sufficient quantity to kill larvæ, they would have a decided effect on the bacterial life of the manure."

Removal of Manure and Receptacles for Its Temporary Storage

The average time elapsing between the laying of the eggs and the issuing of the adult flies, as we have seen, is, in midsummer in the climate of Washington, about ten days. In warmer regions, and with plenty of moisture, it may be as short as eight days. Therefore it is by all means advisable to have manure accumulations

removed at least once a week, although from all points of view aside from that of convenience a removal and spreading every day would be better.

The writer has for some years advised that stables should be fitted with fly-tight pits or closets into which the daily manure may be shoveled, and which at the same time should be arranged conveniently for taking the manure away at intervals of a week. In his first experiment with the old stables of the U. S. Department of Agriculture he utilized a corner closet with a door opening into the stable. An outside door was cut through the wall, and the place was ventilated with screened apertures. The daily manure was shoveled in, and conveniently removed into carts, through the outside door at the week end. And at a large country club, during the summer of 1910, he advised the building of a manure pit in a convenient side hill; the top of the pit being near the stable and at a much higher elevation than the other end of the pit, which was so situated that a cart could be driven before it, the door opened, and the manure readily shoveled out.

The regulations of the District of Columbia provide simply for a covered receptacle, and it has been found that a tight-covered barrel answers the purpose for a one-horse stable.

In Berkeley, California, according to Herms (1910), at such stables a simple galvanized iron-garbage can has been found very useful and convenient, or even a tight barrel covered with a tightly fitting lid. In Berkeley the contents of these receptacles are removed once

or twice a week, either by the city scavengers, or by gardeners for fertilizing purposes. In the case of a large stable, where many horses are cared for, Herms recommends such a closet as was used in Washington, or the construction of a lean-to or shed connecting with the stable by means of a small screened door. Where it is not convenient to construct a lean-to because of sliding doors or other obstructions, he recommends a large bin, either of wood or of concrete, with a hinged top. He illustrates a type of concrete bin used in one of the fire-engine houses in Berkeley, but shows that it is not conveniently constructed, since it is unhandy to remove the manure. It ought not to be difficult to construct a concrete bin with a lidded top, and a lower hinged door from which the manure can be removed conveniently.

The Sanitary Privy

The uncared-for privy, both on farms and in towns, will eventually disappear, and the sooner it goes the better it will be for human health. It is a prolific source of soil contamination and a prolific breeder of germ-laden flies. Who can estimate the number of lives that have been lost through the persistence of this primitive and persistent blot upon conditions of life which might otherwise be called civilized?

Hardly any one realizes the extent to which this semi-barbaric institution exists in many parts of the country, and as a matter of fact I am sure that the average person in the large city has no idea of the

fact that there are many comparatively intelligent citizens who in sanitary matters have not even reached the grade of civilization which demands the sanitary privy. Stiles, in the course of his great work in the Southern States, has brought together some startling figures. He is responsible for the statement that with 4,825 American farmhouses in six different States 2,664, or fifty-five per cent., have no privies of any kind; of 2,499 houses inhabited by white people, thirty-five and three-tenths per cent. have absolutely none, and of 2,326 inhabited by negroes seventy-six and eight-tenths per cent. have none. And what shall be said of the condition of a large part—the very great majority—of those which do exist? The uncared-for privy is still a most important factor all over the United States, even in portions of our most cleanly cities.

In the better class of country houses, especially in summer country communities of city people, efforts have been made to improve this condition of affairs; and it should be said parenthetically that the influence of these summer country communities of city people upon the general conditions of the life of the country people around them is of great and growing value, for the imitative turn of mind of the young country people is overpowering the conservatism of the older individuals.

But the attempts which have been made even in some of these summer colonies to attack the privy question have not been at all satisfactory. The earth closet has had a great vogue and still remains to a great

extent. Confining ourselves strictly to the fly question and to no other, an earth closet unprovided with a removable bucket and from which the contents are removed only at considerable intervals is little better than the uncared-for privy, except that it is usually less accessible to flies. A slight covering of earth over the contents is no protection against the emergence of adult flies coming from larvæ within the substance. It is not a protection against infestation from flies coming in from outside, since these have been shown to lay their eggs upon the earth covering excreta. When the eggs hatch, the young larvæ, being very active, soon burrow to their proper food.

Accurate experiments have been made by several observers concerning the distance which the newly emerged fly will struggle through earth to the air. Hine (*in lit.*) experimented with ordinary soil and found in a single experiment that adults were not able to emerge from a depth of six inches, but Stiles and Gardner, of the U. S. Public Health and Marine-Hospital Service, have shown that, in experiments with sterilized sand, house flies to the number of thirty-seven, issuing from fecal material buried in a screened standpipe under forty-eight inches of sand, came to the surface. Some of these flies were sent to the writer's office for determination and were named by Mr. Coquillett. They were in a somewhat damaged condition, due probably to their long struggle for freedom. In the same series of experiments, other flies of undetermined genus and species struggled up to free-

dom through seventy-two inches of sterilized sand, truly an heroic struggle!

Dry earth, therefore, is not satisfactory, although in earth closets provided with buckets removed daily the problem resolves itself into the question of the proper disposal of the contents of the buckets.

In many localities lime is used instead of dry earth. A careful study of the lime system was made by Stiles and Gardner in a certain industrial village of the South. In that village the habit was to clean the outhouses once a week and to distribute the lime free to the families. The people were notified repeatedly that the lime should be used regularly and generously, and the authorities of the village assured the observers that all reasonable efforts were made to carry out the system properly. It therefore seemed to the Government men that this particular village was a very fair case to take as a basis for observations as to the actual workings of the system. Their observations were careful, and they found that in thirty-two instances out of eighty-eight the lime had actually been used, and the conclusion was that, even where lime is furnished free of cost and the people are urged to use it, it is not generally adopted. Moreover, of the thirty-two outhouses in which it had been used, it was freely used in only three cases.

The conclusion was that families cannot be relied upon to use it properly. In not one instance of the eighty-eight did they fail to find exposed night-soil of easy access to flies and other insects. Live fly larvæ were found in all samples taken. It may be mentioned

also, incidentally, that live hookworm eggs were also found. Interesting observations were made upon the practical workings of the cleaning process, which need not be detailed except to state briefly that the process of cleaning was by no means perfect, and that in carrying the cartloads away flies and possibly contaminated flies were distributed here and there and everywhere, while the dump was inhabited by swarms.

The lime system, therefore, is a failure, even if one can rely upon its proper administration, and it is not only a failure, as pointed out by Gardner and Stiles, but *it is an additional menace from the feeling of false security which it gives to the persons who use it.*

It seems, as a result of the experimental work carried on by the observers mentioned above, that surface privies should without further delay be remodeled into a tub, pail, or barrel system, and that water or kerosene and water should be used to kill fly larvæ or hookworm eggs or other dangerous forms found in excreta. Their experiments indicate that a mixture of crude carbolic acid and water will kill the fly larvæ, but on account of the dangers in the use of this mixture they do not recommend it. Water only, placed in the bucket, is not recommended, since not only may live eggs of the hookworm be found in the water at the end of twenty-four hours, but mosquitoes will lay their eggs in the buckets and breed there. A film of kerosene on the surface of water kills everything, including hookworm eggs, round-worm eggs, fly larvæ, and mosquito larvæ. The principal objection to the use of

water with a film of kerosene on top in an ordinary unprotected tub, pail, or barrel system is that if the water is too deep splashing occurs, and a wet system calls for a large receptacle.

In a recent publication, Stiles (1910) covers the whole subject, and gives directions for building a really sanitary privy, indicating that any fourteen-year-old schoolboy of average intelligence in mechanical engineering could, by following the plans given, build a sanitary privy for his home at an expense for building materials, exclusive of receptacle, of from five to ten dollars, according to locality. The plan (directions for its construction are printed as Appendix IV) provides for a fly-proof structure, well ventilated, with a receptacle for the excreta mounted on a floor and protected from behind by a hinged door through which it can be removed. The receptacle always contains the necessary amount of water with a film of kerosene floating on it. The most casual observation will indicate when to renew the water and kerosene and when to empty the receptacle.

Since the publication of the bulletin in question, Lumsden, Roberts, and Stiles, of the Public Health Service, have devised an additional arrangement which they have had in constant use in the Hygienic Laboratory at Washington for several months. Concerning the practical workings of this apparatus they seem very enthusiastic. The writer himself has visited it and found it perfectly unobjectionable after being in use for more than three months without having been

once emptied. A description of the apparatus with a diagram of its construction will be found in Appendix V. Its cost of construction is said to be about $1.40.

There seems no doubt that this invention of the officers of the Public Health and Marine-Hospital Service is the best down to the present time in the way of a sanitary privy. Recommendations, however, have been made in this direction by boards of health and by private individuals. Rev. George W. Lay (1910), for example, has given at considerable length directions for the construction of a good privy, and terms it "The North Carolina Sanitary Privy." He rather holds to the dry-earth view, and mentions kerosene only by stating that if a little of it is sprinkled in the privy box it will have a tendency to keep the flies away.

Kerosene, however, should be used, not so much as a preventive, but as a means of destroying eggs and larvæ. In communities like mill towns, where the majority of the flies breed in the privies owing to the lack of horse stables and horse manure, and it may be found impossible to compel the construction of new sheds, the use of kerosene on the dejecta will be effective.

In 1906, the Paris journal *Le Matin* offered a prize for the best methods of destroying flies. The competition attracted a great deal of attention, which was fostered by the newspaper by frequent articles. The prize was finally awarded to an anonymous writer who proposed to pour green oil of schiste in privies and upon manure piles, mixing it in the latter case with

earth or lime. The oil of schiste is a crude petroleum found in Europe. In the number of July 19, 1907, the paper stated that this proceeding had given excellent results and that flies had disappeared wherever it had been applied. At the International Congress of Hygiene in Berlin following, Professor Bordas confirmed the statements of *Le Matin,* and added that the Governor of Kiaotscheau had obtained excellent results by the oil method. Galli-Valerio (1910), being greatly interested in this matter, wrote to Doctor Dirksen, physician to the Government at Tsingtau, and found out that only five liters of the oil of schiste were sent to the Governor by *Le Matin,* and thinks that the results of work on such a small scale are not at all convincing. Experiments made by the writer, however, with the use of kerosene upon horse manure, convince him that it will act equally well in privies, and in this statement he has the endorsement of Stiles and others.

A Compulsory Sanitary Privy Law

The following paragraphs, quoted from Stiles (1910), excellently express some very sound ideas on this subject.

"A compulsory sanitary privy law or ordinance should exist and be strictly enforced in all localities in which connection with a sewer system is not enforced.

"Since, from a sanitary point of view, the privy is a public structure in that it influences public health, it seems wisest to have city and town ordinances which provide for a licensing of all privies, the license being

fixed at a sum which will enable the city or town to provide the receptacles (tub, pail, etc.), the disinfectant, and the service for cleaning. The expense involved will vary according to local conditions, such as cost of labor and density of population. If the "chain gang" can be utilized for cleaning, the expense for labor is reduced.

"The importance of taking the responsibility for the care of the privy out of the hands of the family is evident when one considers that one careless family in ten or in a hundred might be a menace to all. The removal of garbage and of ashes is recognized as a function of the city or town in all better-organized communities, and the idea is constantly spreading that this service should extend to a removal of the night-soil also.

"In correspondence with certain cotton mills, estimates for privy cleaning (once a week) vary from about twenty to twenty-five cents per privy per month. A privy tax of $3.50 to $5 per privy per year ought to give satisfactory service, including receptacle, but the exact amount of the tax must be determined by experience in each locality.

"It is probably the exception that an economical public privy-cleaning service can be carried out in the open country, on account of the distances between the houses. To meet the difficulties involved, several suggestions may be considered, according to conditions:

"A country privy tax can be levied, the county can furnish the pail and the disinfectant, and (1) one mem-

ber of each family or of several neighboring families hired to clean the privy regularly; or (2) the landlord can be held responsible for the cleaning of all privies of his tenants, receiving from the county a certain sum for the service; or (3) "trusties" from prisons might possibly be utilized in some districts not too sparsely settled; or (4) a portion of the county privy tax might perhaps be apportioned by school districts and be distributed as prizes among the school boys who keep their family privies in best condition; or (5) each head of family might be held responsible for any soil pollution that may occur on his premises and be fined therefor.

"Undoubtedly the problem of the privy cleaning in the open country is much more difficult than in cities, villages, and towns, and in the last instance involves a general education of the rising generation of school children, more particularly of the girls (the future housekeepers), in respect to the dangers of soil pollution."

The Capture of Adult Flies Outside of Houses

Under this heading, the plan proposed by Professor Hodge, mentioned in the introductory paragraphs of this chapter, must be considered. His idea, it will be remembered, is to catch the adult flies before they lay their eggs and before they become a nuisance in houses. Isolated observations by Dr. C. Gordon Hewitt have shown, as elsewhere stated, that in England ten to fourteen days elapse after an adult female fly issues

before she lays her eggs, and it is during this period that Hodge proposes to catch her.

It is interesting to know the way in which the idea came to his mind. In a paper entitled "Extermination of the Typhoid or Filth Fly, a Plan of Campaign," read before the annual meeting of the American Civic Association in Washington in December, 1910, he shows that for eight years previously he had amused himself in the summer by rearing native birds, especially the ruffed grouse and the bob-white. The enormous quantity of insect food required by the young chicks led him to what seemed to him the most effective plan of dealing with the fly problem. He needed flies with which to feed his chicks, and the problem was to get flies in the greatest numbers possible.

Having perfected what seemed to him an excellent method of accomplishing this, he began to argue as to the use of his idea as a substitute for the treatment or removal of the manure pile or the treatment or removal of all substances in which flies will breed. Thinking of the enormous multiplication of the offspring of a single pair in the springtime, he asks the pertinent question, "Why not catch the original pair of flies in April?" After studying the problem for some time, he became so enthusiastic over the prospect that in his address he uses the following sentence: "If, beginning next spring, every family will adopt effective measures to kill the few hundred flies that succeed in surviving the winter, I am convinced that we could relegate our window screens to the scrap heap, so far

as our protection against *Musca domestica* is concerned."

He plans certain lines of attack, all directed against the adult fly out of doors. The first of these lines consists in the effort to trap the flies at their source of food supply. On the supposition that everything in the way of waste food which is attractive to flies is or can be placed in garbage cans or swill barrels, he believes that a double wire screen trap can be attached to this receptacle in such a way as to catch every fly that is attracted to it. He shows that in some cities the rules of the boards of health require that all such receptacles should be tightly covered. He considers that this is a serious mistake, since it drives the flies from the garbage into the kitchens. The garbage cans, to his idea, can be made so attractive as to draw the flies out of the kitchens and focus them at one spot and catch them as soon as they come. As fast as the traps are filled, the contents are scalded and removed and fed to chickens or put into the garbage can.

He has devised a trap attachment to garbage cans with which on one occasion he caught 2,500 flies in fifty-five minutes. This was back of a market in an ice-cream stand. The can was baited with fish heads, meat scraps, watermelon rinds and green corncobs, over which the melted waste from the ice-cream freezers was poured. The cover of this can was held up by strips of metal soldered to the can so as to keep about a quarter of an inch fly space entirely around the can through which the flies could enter. Then a

Fig. 20.—Fly trap for garbage cans; designed by Prof. C. F. Hodge.

wire gauze trap was set over a hole on the sunny side of the top of the can. The flies crawled in, attracted by the odor of food, and attempted to escape by the only opening through which the light came, thus entering the trap.

Another form devised by Hodge had a tight can cover, the trap being contained within the cover. The trap itself forms the only entrance to the can, and the flies attracted by the odor enter the trap. Another trap devised was a wire gauze cylinder fitting over a tomato can, the can being filled with attractive substances, and the trap being arranged so as to be scattered around stables or barnyards or wherever flies happen to be congregating or breeding.

He made still another arrangement for a screen for a stable cellar or manure pit window, making a small hole in the screen near the top and providing the screen with narrow strips of tin or wood to guide the flies to the hole; the hole, of course, leads into a wire gauze trap, where all the flies that emerge will be caught. In the same way he made another, also provided with guiding strips, on the outside, and furnished with a trap on the inside, so as to catch all of the flies that might be attracted to the stable to lay their eggs. This latter idea he has not yet tested, but he argues that if the outside flies were shut out by screens they would certainly find some other breeding place in which to lay their eggs.

On the habit that flies have of being attracted to kitchens by the odor of the cooking or by the warmth

on cool nights, he bases another line of attack, which is to make a hole in the window screen, with the guiding strips outside and the trap inside, thus catching all the flies that attempt to enter the kitchen in that way. He has tested this device, but thinks that it cannot compete with the garbage-can trap.

Professor Hodge (1910) points out that there is much yet to be known about the biology of the adult typhoid fly, its favorite foods, its needs for water, its habits in seeking shelter, length of life, and the distance it flies, but he thinks that what little we know indicates that the strategic point of attack is the adult. He states that we have been long working on this theory unintelligently and ineffectively with sticky or poisonous fly paper and traps, but that these means have been employed only to kill the comparatively few flies that gain entrance to our houses.

"Carry the war into Africa; develop the means of attack seriously and effectively in the out-of-doors, and I fully believe that there will be no filth flies to go back to the compost heaps and barnyards to lay their eggs." After using his traps for a period, he found it possible to dine on the porch; as he expressed it, he had turned the tables on the flies, and put them in a prison and let himself out. Hodge wishes to stimulate invention towards making effective out-of-doors fly traps, and he urges experiments with different baits. He states that he did enough in the summer of 1910 to be convinced that any country home "a half mile away from its nearest ignorant neighbor, or any town-

or city, could completely exterminate the filth fly by intelligent and co-operative effort during the months of April and May (and possibly June) of any year."

In this connection it may be well to call attention to the device invented by Kellers (1911), which is a wire gauze garbage-can holder which will contain several garbage cans. It allows daily inspection and free circulation of air. It aids in the suppression of the fly nuisance and the prevention of the scattering of putrescent material by rats, cats, and other animals. The designer of the holder is a hospital steward in the United States Navy, and the one first designed is in use at the U. S. Naval Hospital, Puget Sound. Some such arrangement for hospitals and other similar institutions will be excellent, and the addition of Hodge's fly-trap idea will be easy.

Special Considerations for Towns and Cities

In the country, the individual householder should care for his own surroundings in such a way as to free himself from flies, but in communities this will not be effective. A single stable owner by the proper care of his manure may greatly reduce the local supply, but there will still be many thousands from other stables in the neighborhood and from other possible breeding places nearby. It becomes necessary therefore that an organization of some kind or some system of co-operation should exist in communities.

Organization

In a number of towns and cities in the United States, the initiative in the fly crusade has been taken by health officers, but in the majority of communities the health officials have to be stirred up. In some cases, as in the State of Florida, the whole State crusade has been begun by the State officials and they have stirred up the town officials. In a few communities—but these are very few—private practitioners have been the exciting cause of anti-fly work. In one State only, so far as the writer knows, has the State medical association established a fly committee which has taken it upon itself to carry information concerning the typhoid fly into every portion of the State.

Elsewhere, and here are the majority of instances in which anti-fly work has been begun, the beginnings have been made either by a single private individual or by some local organization, as a civic league, a women's club, or a town improvement society. Women's clubs have done very effective work in this direction, and it may be parenthetically stated that a great latent power exists in these organizations, a power which is only just beginning to manifest itself. The energy shown for years by these organizations, while never misdirected, has not until very recently been directed towards the work which is the most productive for the good of all, namely, general sanitary measures with a focusing upon one point after another. The Women's Municipal League of Boston, as an example, has re-

cently taken up the fly question through its department of sanitation, of which Mrs. Robert S. Bradley is the chairman, and is doing admirable work.

In most communities nowadays, one or the other of these organizations or all of them exist. In towns where there are no such organizations, they should be started at once. In such cases let any one convinced of the necessity for an anti-fly crusade talk to his or her friends and, unrebuffed by indifference on the part of others, persevere until a group is formed. Then with perseverance the growth of the organization and the growth of public spirit in many directions will be rapid.

The first effort of such an organization should be to enlist the sympathy and co-operation of the health authorities of the community. This gained, every possible effort should be made to induce the controllers of the appropriations for the health officials to realize the importance of this work. Health officers without funds at their disposal for the employment of inspectors and for the carrying out of regulations are hopeless, and therefore the first step, after the health officials themselves are convinced of the desirability of the work, is to secure the funds. In some cases this has been done by private subscription, the money to be expended under the supervision of the health officers. In other cases private individuals with sufficient leisure have had themselves appointed as health inspectors without salary, but by virtue of the appointment they are armed with the legal authority which the health board has.

Continuous and successful voluntary work of this kind, however, is not to be relied upon, and the campaign for funds, and preferably for regularly appropriated funds, must be a strenuous one.

Before all this, however, a campaign of publicity must be inaugurated, and in such a campaign the local newspapers are of great assistance; in fact in many cities during the summer of 1910 the local newspapers themselves inaugurated the campaign. Four excellent instances of this which have come under the writer's observation are the campaigns begun and carried through the summer by the *Minneapolis Tribune,* the *Kansas City Star,* the *Milwaukee Sentinel,* and the *Washington Evening Star.*

Mr. Leroy Boughner, city editor of the *Minneapolis Tribune,* wrote up his newspaper anti-fly campaign in an excellent paper which was read before the December, 1910, meeting of the American Civic Association, and in his introductory paragraph he made the following explanation:

"An intelligent newspaper campaign against the house fly is not only a great benefit to the community in which the newspaper circulates, but it is of direct value to the newspaper itself, both in the increased prestige it gets as a sponsor for civic betterment and in the advertising that accrues from dealers in screens, drugs, and sanitary appliances. The campaign conducted by the *Minneapolis Tribune* in 1910 accomplished both results, and the story of how it was done is an interesting one." Could any but an

experienced newspaper man have written that paragraph?

Mr. Boughner goes on to describe how the literature furnished by the American Civic Association and by various State and city boards of health and other organizations was collected and from these were culled hundred-word articles, general in nature, but prepared in such a way as to attract the attention of every reader. These were started in April, and after they had been running for a week or so letters were sent to every club in Minneapolis suggesting that they endorse the campaign, and these resolutions kept coming in for a month or more, and were printed, giving a local tinge to the campaign. Then the local and State health officials were interested and were quoted wherever it seemed necessary. Then the State Entomologist was approached, and he was quoted. The use of gruesome pictures was avoided as a rule, but occasionally the readers were startled with a statement and a picture that helped to intensify the interest. When the Tuberculosis Committee of the Associated Charities advised drug store keepers to cover their wares, the *Tribune* took the matter up and drew a fly moral from it. Very often it happened that the ammunition furnished by this paper was most valuable, and as an example Mr. Boughner states that seven cases of typhoid in a suburb of Minneapolis were traced to the typhoid fly. Every change of weather was used as a pretext for a new editorial, and at the conclusion of the campaign a big story was written summing up the results.

As a rule the newspaper can be relied upon in such a meritorious campaign as this, and city editors should if possible be placed upon the committees of the civic organizations. The newspapers, however, should be supplemented by posters, and by tracts explaining the whole situation in a few striking sentences. This has been done very extensively in some cities. It is important that the organization should not rest with a single poster or with a single tract, but the subject should be emphasized again and again, just as some of the newspapers did last summer. In this way the whole community becomes at least educated upon the subject, and, with a very general knowledge of the fact that flies are dangerous as well as burdensome and of the fact that they can be controlled, a great step has been gained. In other words, with this education practically the whole community will be found to support the movement.

Let us take the case of a community in which such work has not yet been undertaken; let us suppose it to have been started in any one of the ways which we have mentioned; let us suppose that an organization has been perfected or is in process of being perfected, and that the campaign for publicity is about to begin. The easiest way to get ammunition is to write to the Secretary of the American Civic Association, Mr. Richard B. Watrous, whose address is Union Trust Building, Washington, D. C. The fly Committee of this association, of which Mr. Edward Hatch, Jr., of New York, is the chairman, has done some very energetic

work, and the whole association seeks the opportunity to co-operate directly with civic societies of every character, such as women's clubs, local civic leagues, consumers' leagues, school improvement societies, and all organized bodies, in a direct crusade against the typhoid fly.

The association publishes bulletins with full information as to the life history and habits of this fly and with the most practical suggestions, secured after conference with the leading physicians and entomologists. These bulletins are sent to societies in quantities, but there is sometimes a small charge for very large quantities. The association also co-operates directly in providing press clipping sheets that may be used to great advantage with local newspapers, calling attention to the dangers in permitting flies to breed unrestrictedly. It maintains also a department of lantern slides, which includes a large collection of pictures, some of them descriptive of the life history of *Musca domestica*, and others being reproductions of striking cartoons from the newspapers, and of effective posters that have been used by health boards and may be used for display in public places, such as shops, railroad stations, and on the street cars, to call attention to the dangers surrounding the existence of the fly. It has also a very effective moving-picture film which can be rented by societies and which is a most effective manner of presenting vividly the objectionable habits of the house fly.

The association has also, for use by societies willing

to pay express charges, a large cabinet containing exhibits of every character, such as posters, bulletins, and actual pictures of flies in their breeding places and as distributers of disease. This cabinet can be set up in public places to great advantage. One of the pictures in this cabinet indicates the air-line flight of the typhoid fly from the garbage pail to the breakfast table; another shows a stable with an enormous manure pile, and enlarged figures on the development of the fly. A third pictures food exposed on the streets and swarming with flies. A fourth is a photograph of a privy vault swarming with flies, close to the kitchen door. Another is a reproduction of the striking fly poster of the Florida State Board of Health (shown in Fig. 21). An admirably worded placard reads, "If there is any contagious disease in the neighborhood, beware of flies."

Interesting the Children

Considering the exasperating conservatism of the public at large when the anti-mosquito campaigns began to be inaugurated ten years or more ago, and the fact that even after mosquitoes had been written about and preached about until it would seem that no intelligent citizen in the country could have failed to be convinced of such admirably demonstrated facts as the carriage of malaria and yellow fever by certain of these dangerous creatures, and of the perfect practicability of a startling reduction in their numbers by the expenditure of a certain amount of money and hard work, the majority still remained ignorant or unconvinced;

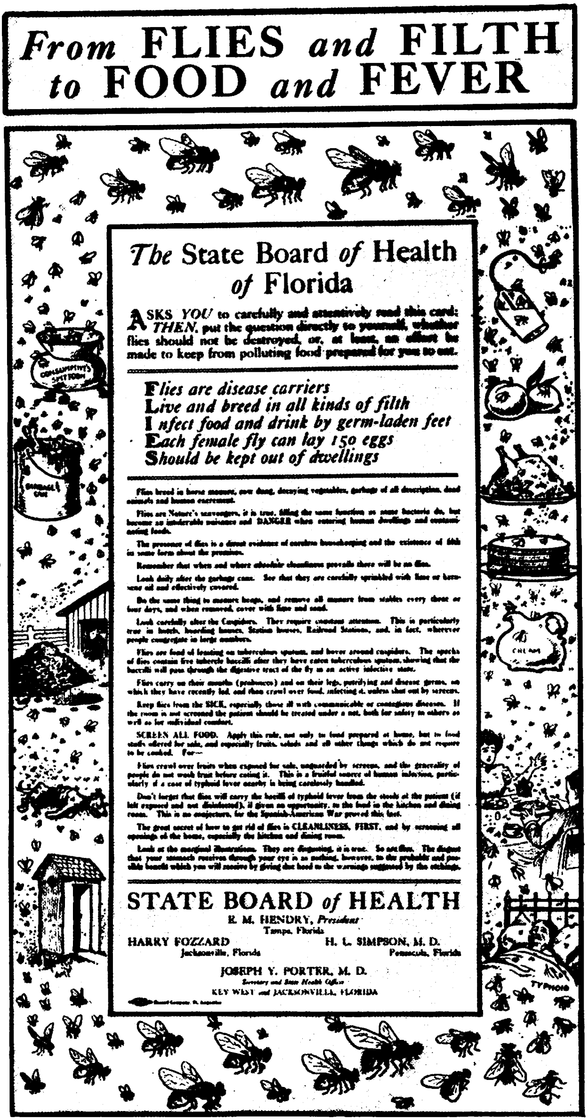

Fig. 21.—Poster issued by the Florida State Board of Health; greatly reduced.

considering this delay, it is a delight to see the comparative rapidity with which the anti-house-fly idea is spreading. Possibly had this latter crusade been begun first it would not have moved so rapidly; possibly the education which people have had in regard to mosquitoes makes them more ready to accept the ideas that are being put forward by the anti-fly movers.

But in the case of mosquitoes, in more than one community it was found absolutely impossible to do anything with the adults, and education was begun with the children in the schools. Probably the first of this work was carried on by Prof. C. F. Hodge in Worcester, Mass., in 1901 or 1902, and he was very successful in interesting the school children in the search for mosquito breeding places.

The most serious and productive effort, however, was made at San Antonio, Texas, a year or two later, at the initiative of Dr. J. S. Lankford. The school board approved the idea of endeavoring to educate all of the school children of the city in prophylaxis, and to make sanitarians out of all of them. The best medical literature on the subject was procured and furnished to the teachers. A circular letter was sent to them outlining the proposed course, and offering a cash prize for the best model lesson on the subject. Teachers became greatly interested; a crude aquarium with eggs and wrigglers was kept in every schoolroom where the pupils could watch them develop, and large magnifying glasses were furnished in order that they might study to better advantage. The children were en-

couraged to make drawings on the blackboard of mosquitoes in all stages of development. Lessons were given; compositions were written on the subject; competitive examinations were held, and groups of boys and girls were sent out with the teachers on searching expeditions for the breeding places.

Rivalry sprang up between the 10,000 public school children in the city in finding and reporting to the health office the greatest number of breeding places found and destroyed. Records were kept on the blackboards in the schools of the progress of the competition, and great enthusiasm was stirred up. In addition to these measures a course of stereopticon lectures was arranged, grouping the pupils in audiences of about 1,000, from the high school down, and in Doctor Lankford's words, "It was an inspiring sight to watch these audiences of 1,000 children, thoughtful, still as death, and staring with wide-open eyes at the wonders revealed by the microscope. It seemed to me that in bringing this great question of preventive medicine before public school children we had hit upon a power for good that could scarcely be over-estimated." As a result there was a decided diminution in the numbers of mosquitoes in San Antonio. There was some opposition among the people, but the movement on the whole was very popular, and the mortality of the city from malarial trouble was reduced seventy-five per cent. the first year after the work was begun, *and in the second year it was entirely eliminated from San Antonio!*

It follows that in organizing community work, not only against mosquitoes but against flies as well, the school children must be counted upon as a most important factor. Almost all children are born naturalists, and interest in such things comes to them more readily than anything else outside of the necessities of life. They are quick-witted, wonderfully quick-sighted, and as finders out of breeding places they cannot be approached except by adults with the most especial training.

The specific question of interesting school children in the house-fly campaign was brought up at the December meeting of the American Civic Association. It was introduced by the writer and had also been previously considered by the Fly Committee of the association, of which, as previously stated, Mr. Hatch is the chairman. The association plans to offer prizes for school children in certain selected cities, prizes aggregating for the ordinary town say from thirty to fifty dollars. These are to be competed for by children of the public schools, and in two classes: first, young children between the ages of nine and eleven; and, second, children from twelve to fifteen; so that the younger children will not come into competition with the older and presumably better prepared ones.

It will be necessary in order to do this, in some cases, to do a little work with school boards, so that they may be willing to admit into the schools the literature which will be the basis of the essays. Health boards

and medical societies, however, will naturally be willing to co-operate. The association hopes that there will be public-spirited citizens in the various towns who will themselves institute competitions of this sort.

Referring to this matter, in a paper read later at the meeting, Doctor Woods Hutchinson said, "I believe that we could utilize an enormous amount of good enthusiasm and good human activity going to waste under the name of 'mischief,' and if we could take the enthusiasm of a boy and his delight of getting into mischief and put him to work on the fly problem, I believe we could do a great deal towards putting any community into a practical process of cleansing."

An important point which we have not yet mentioned is that it will be important to have one or more well-posted physicians on the advisory board of any fly-fighting organization, in order that the tendency of enthusiastic people to make extreme statements which are unscientific and not perfectly justified by facts may be held within bounds by others posted as to scientific methods and as to the exact truth of the sanitary aspects of the crusade. The advisory committee, and especially its medical members, will find themselves much embarrassed by the difficulty of refraining from over-statements.

The fly situation is an extremely bad one in all truth, but if it is exaggerated in order to attract and intensify universal popular interest, the very exaggeration

will have the contrary effect upon the minds of conservative people, and upon medical men who stand for absolute exactness of statement. Moreover, there are in every large community scientific men trained in laboratory methods, who believe that exact truth can be obtained only by laboratory methods and who hold the verdict of "not proven" against certain things which on the strongest circumstantial evidence have been claimed against the fly. It is best to carry this conservative class with you if you can, and this can be done by a certain moderation in statement and by the avoidance of methods which may be termed ultra-yellow-journalistic.

And there is the quandary: how to frighten the ignorant and slothful and educate them on the fly question without creating a distaste for your methods and a consequent lack of helpful interest on the part of some who could be of the most valuable assistance. The writer, although he was trained to scientific methods and has followed them for many years, is inclined to think that over-statement to bring about a great sanitary reform may be justified so long as this over-statement is based upon sound circumstantial evidence.

He is thoroughly optimistic as to the progress, in the immediate future, of the campaign of education against the typhoid fly, and he is certain in his own mind that, take the country by and large, and including all classes of citizens, whether living in cities, towns, villages, or on farms, there is no single way in which the mortality rate of the country can be so rapidly de-

creased, and, *per contra,* the health of the people so easily bettered, as by the reduction of the numbers of the house fly to a negligible quantity.

Boards of Health

The health officers, both State and local, of the country have their associations and organizations of one kind or another. Probably all of them are members of the Public Health Association of the United States. All are thus, or should be, acquainted with the work of all the rest, since there is a constant interchange of ideas at the meetings and a constant interchange of publications in the intervals between the meetings. But it is well for citizens' associations, civic leagues, women's clubs who take up sanitary matters, and public-spirited citizens generally, to know what an effective health officer or board of health should do, in order that they may intelligently criticise the administration of such matters by their own local officials in case, when, as it sometimes happens, these are lax; or, on the other hand, back up efficient officials where village trustees or town councils or city boards of aldermen are not disposed to grant the funds necessary to carry out proper sanitary regulations.

This is our excuse for quoting at length the sanitary regulations of the District of Columbia in so far as they relate to the fly problem. The regulations are sound and the citizens of the District have no cause in this respect to criticise the health officer, but the appropriating body in this case (and it happens to be

the Congress of the United States) has not down to the present time appropriated sufficient funds to carry these regulations into full effect. Good regulations require an efficient force of inspectors, and efficient inspectors must be paid. Dr. William C. Woodward, the health officer of the District, has called the writer's attention to the fact that it really requires, from the practical standpoint, two inspectors to do one inspector's work, since a solitary inspector, coming into court with a charge of violation of the regulations against a given citizen, is invariably confronted with such a mass of testimony against his charge that he is sworn out of court. He must take some one along with him to prove it. The orders in question may be briefly condensed as follows; their full text will be found in Appendix III:

All stalls in which animals are kept shall have the surface of the ground covered with a water-tight floor. Every person occupying a building where domestic animals are kept shall maintain, in connection therewith, a bin or pit for the reception of manure, and pending the removal from the premises of the manure from the animal or animals shall place such manure in said bin or pit. This bin shall be so constructed as to exclude rain water, and shall in all other respects be water-tight, except as it may be connected with the public sewer. It shall be provided with a suitable cover and constructed so as to prevent the ingress and egress of flies. No person owning a stable shall keep any manure or permit any manure to be kept in or upon

any portion of the premises other than the bin or pit described, nor shall he allow any such bin or pit to be overfilled or needlessly uncovered. Horse manure may be kept tightly rammed into well-covered barrels for the purpose of removal in such barrels. Every person keeping manure in any of the more densely populated parts of the District shall cause all such manure to be removed from the premises at least twice every week between June 1st and October 31st, and at least once every week between November 1st and May 31st of the following year. No person shall remove or transport any manure over any public highway in any of the more densely populated parts of the District except in a tight vehicle, which, if not inclosed, must be effectually covered with canvas, so as to prevent the manure from being dropped. No person shall deposit manure removed from the bins or pits within any of the more densely populated parts of the District without a permit from the health officer. Any person violating any of these provisions shall, upon conviction thereof, be punished by a fine of not more than forty dollars for each offense.

In addition to this excellent ordinance, others have been issued from the health department of the District of Columbia which provide against the contamination of exposed food by flies and by dust. The ordinances are excellently worded so as to cover all possible cases. They provide for the registration of all stores, markets, cafés, lunch rooms, or of any other place where food or beverage is manufactured or prepared for sale,

stored for sale, offered for sale, or sold, in order to facilitate inspection, and still more recent ordinances provide for the registration of stables. An excellent campaign was begun during the summer of 1908 against insanitary lunch rooms and restaurants. A number of cases were prosecuted, but conviction was found to be difficult for the reasons already mentioned.

All boards of health should follow, and doubtless are following, the very interesting experiment which the Louisiana Board is now making, of sending out a "Health Train" and visiting one town after another, conducting health demonstrations and lectures and showing moving pictures which appeal directly to the intelligence of every one. Three hundred and fifty towns in Louisiana have already been visited in this way; and education on the house fly has been a very important part of the work. The first train was sent out from New Orleans November 5, 1910, and consisted of two especially equipped cars. An illustrated article on the subject was published in the Quarterly Bulletin of the Louisiana State Board of Health, i, No. 4, November 15, 1910.

Army Camps

The severe lessons of the past in regard to fly-borne typhoid in army camps have borne fruit, and there is reason to believe that among the more civilized nations in the future there will be no recurrence of the frightful experiences of the summer of 1898 and of those in South Africa. It is with the greatest pleasure that the

writer learns, just as this book is going to the press, of the regulations in force at San Antonio, Texas, in the large encampment of troops there present. The camp sanitary regulations appear to be of the most perfect kind and to be admirably enforced. An account of the methods used will doubtless soon be published by the Medical Corps of the Army, and the writer refrains from anticipating such publication, since the observations on which he bases this statement of the perfection of the arrangements have been made by persons not connected with the service. He may state however that the Medical Corps deserves the greatest praise for the introduction of novel and very perfect arrangements for the disposal of all camp waste.

V

OTHER FLIES FREQUENTING HOUSES

IN a series of experiments carried on during the summer of 1900, flies were collected in the kitchens and dining-rooms of many houses in many different parts of the country. These collections were made in the States of Massachusetts, New York, Pennsylvania, District of Columbia, Virginia, Florida, Georgia, Louisiana, Nebraska, and California. In all, 23,087 flies were thus collected. On critical examination in Washington by Mr. Coquillett, 22,808, that is to say, ninety-eight and eight-tenths per cent. of the whole number captured, were *Musca domestica*. The remainder, consisting of one and two-tenths per cent. of the whole, comprised various species, none of them of any especial significance. These and a few others will be considered in more or less detail in the following paragraphs.

Of course there are other flies than these occasionally found in houses, and some quite commonly so. Mosquitoes are flies, that is to say, they belong to the order Diptera, but they form no part of the present book: they are treated in other volumes. Aside from those especially mentioned here, other flies of the same group are occasionally found, not attracted to a house, but trying to escape from it. Occasionally, however, some

of the biting flies known as gad flies or horse flies, of the family Tabanidæ, enter houses seeking blood. They bite painfully, but for the most part prefer to stay out of doors, although they frequent shady situations as a rule. They are common in pine woods, and the inhabitants of summer houses built in such locations are occasionally bothered by them to some extent. Travelers in Alaska, where some of these gad flies abound during the short and damp summer, have stated that they sometimes become almost a scourge in the cabins.

The species which we are about to mention more fully, however, are the commonest of the flies found in houses, although their numbers are so insignificant as to be almost disregarded when compared with *Musca domestica*.

The Cluster Fly (*Pollenia rudis* Fabr.)

There is a rather sluggish fly, a little larger than the house fly, which is frequently found in houses, especially in the spring and fall. It has a dark-colored, smooth abdomen and a sprinkling of yellowish hair. It is very sluggish, in the fall especially, and at such times it may be picked up readily. It is subject to the attacks of a fungous disease which causes it to die upon window panes, where it is often seen surrounded with a white efflorescence. (Fig. 22.)

The cluster fly is a European species, and the date of its introduction into the United States is not known. It could easily have been brought over upon slow sail-

ing vessels, especially in the cooler season of the year, since it apparently hibernates in the adult condition and seeks the shelter of cracks and crevices. It is mentioned by Loew in 1864 as one of the flies common to Europe and America. Attention was first particularly called to it and to its house habits by Dr. W. H. Dall, of the Smithsonian Institution. In an article published in the Proceedings of the U. S. National Museum for 1882 (Vol. V, pp. 635-636) Doctor Dall related that for several years he had heard of a fly which was a great nuisance in country houses near Geneva, N. Y. He secured specimens of the fly, which were turned over to professor Riley for identification.

One of his relatives in Geneva wrote him that it was probably thirty years since the fly had first appeared in that neighborhood. They were at once a terror to good housekeepers and a constant surprise, since they were found in beds, in pillow slips, under table covers, behind pictures, in wardrobes, and in all sorts of places. In clean, dark bedchambers seldom used, they would form in large clusters about the ceilings. They seemed oily, and if crushed left a great grease spot on the floor. The correspondent stated that about the first of April they came out of the grass and flew up to the sunny side of houses, which they entered. They remained in evidence until some time in May, and then disappeared and were not seen again until September, when they came and remained all winter. They were stated to be very sluggish—to crawl rather than to fly away when disturbed. They were said to be often found in incred-

ible numbers under buildings, between the earth and the floor.

Dr. J. A. Lintner, in his Ninth Report of the State Entomologist of New York (Albany, 1893), gave a number of instances of like occurrences of this fly in houses, both in spring and in winter, in various parts of New York State. A good description was given by a correspondent of the Washington Bureau of Entomology, living in Lasalle County, Illinois. The correspondent stated that the cluster fly had been a pest in her household for fifteen years. She wrote, "They seem to prefer to occupy the rooms on the north side of the house and those that are used but little. They gather in large bunches in the corners and along the edge of the ceiling of the room. They cannot be driven out as other flies, but must be killed outright to get rid of them, and when you mash them the odor is like that of honey. We have tried nearly everything that we heard of that was recommended to us, with no effect. It seems impossible to get rid of them or to keep them out of the house, for they crawl in through the smallest places in the windows."

Other correspondents have reported the odor of the crushed bodies as being very disagreeable.

Incredible as it must seem, practically nothing is known about the early stages of this abundant and troublesome fly. European writers either admit that they know nothing about it or give rather vague statements. Robineau Desvoidy, speaking of the genus Pollenia as a whole, states that their eggs are laid in decomposing

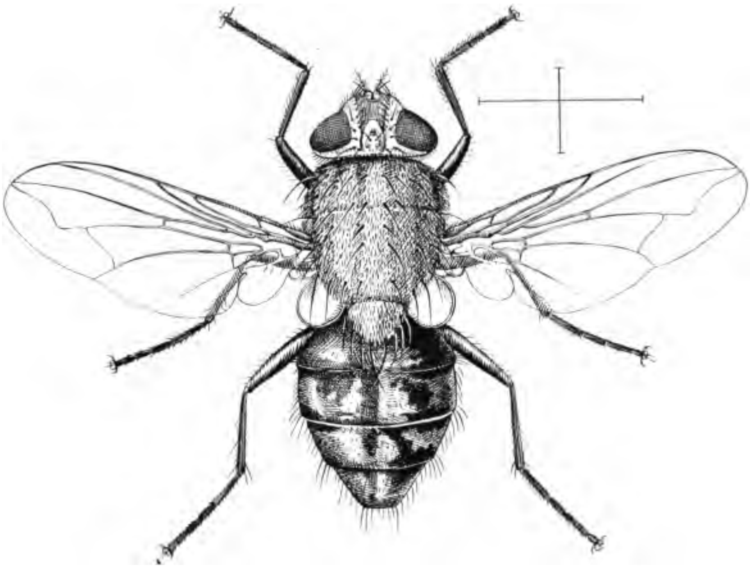

Fig. 22.—The cluster fly (*Pollenia rudis*) ; greatly enlarged. (Original.)

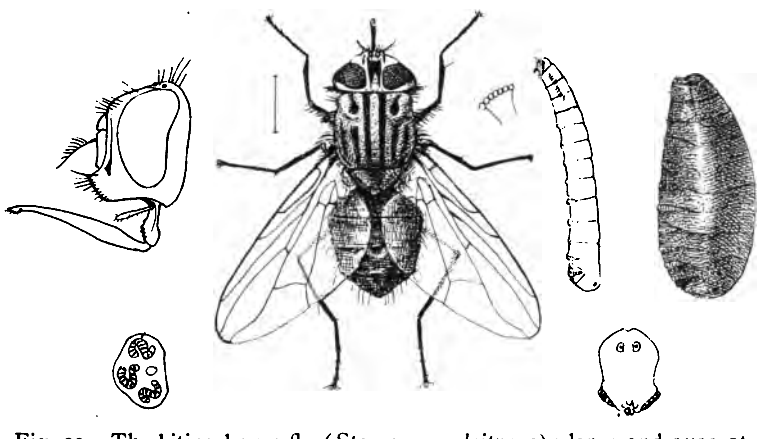

Fig. 23.—The biting house fly (*Stomoxys calcitrans*) ; larva and pupa at right; head at left and anal spiracle of larva below; greatly enlarged. (Author's illustration.)

animal and vegetable matter. Macquart, also speaking of the genus and not especially of this species, states that the larvæ develop in the manure pile and cow droppings. The only definite recorded observation which seems to have been made upon the actual breeding habits of this species, in fact, is the rearing of a single specimen from cow dung. This single specimen was reared in the Insectary of the Bureau of Entomology December 23, 1899. The writer has, however, received a letter from Prof. J. S. Hine, of the Ohio State University, in which he states that during the summer of 1910 he reared numbers of cluster flies, together with other dipterous insects from accidental cow droppings in the pasture.*

In the absence of further exact observations, it is fair to suppose that the cluster fly breeds in decomposing animal matter of some kind or other, and it is altogether likely that measures taken against the breeding places of the true *Musca domestica* will also be measurably effective against this species. There is as yet, however, the possibility that it may breed in rich soil or decomposing vegetable substances. It is difficult to keep out of the house by screening, but it may be killed by a light kerosene spray or by the free use of a fresh pyrethrum powder.

Marlatt (Insect Life, Vol. IV, 1891) records an extraordinary mortality among these flies which he noticed on the grounds of the Department of Agriculture in the autumn of that year. He found often as many as eight or ten flies fastened by a fungous growth to

*D. Keilin (C. R. Soc. de Biologie, Vol. 67, p. 201) states that the larvæ of Pollenia are parasitic in certain earth-worms.

the under side of leaves near the buildings. Specimens of these fungus-infested flies were sent to Doctor Thaxter of Harvard University, and the organism that killed them was found to be, not *Empusa muscæ,* as was thought, but *Empusa americana.*

THE BITING HOUSE FLY (*Stomoxys calcitrans* L.)

This insect is rather closely related to the house fly and greatly resembles it in appearance, in fact it is difficult to distinguish one from the other except by the closest observation. Raillet has stated that the Stomoxys holds its head up while the house fly holds its head down, but there are other ways of telling them apart, as can be seen by comparing the illustrations of the two species. The Stomoxys is of the same gray color with dark lines, but its mouth parts are quite different; in fact a good way to distinguish between the two flies is to allow them to walk over your hand; if it bites, Stomoxys; if it does not it is probably the house fly. It is this other species about which we are writing that gave rise to the old saying that flies begin to bite before a rain, since the biting house fly is not normally a house fly at all, but loves the out-of-doors.

It has not yet and probably never will become as truly a domestic species as *Musca domestica.* It is not attracted to the garbage pail and the kitchen and dining-room for food, but finds plenty of food on cattle and horses and other domestic and also wild animals. Under certain circumstances, however, it may become a very common resident of houses. (Fig. 23.)

Dr. John B. Smith, at a meeting of the Entomological Society of Washington, once stated that these flies were very abundant at his house; that he had not been able to observe any increase in numbers in rainy weather, but on the contrary he had found them gradually becoming more abundant until at that time (November 1st) they had almost replaced the common house fly, which was being rapidly killed off by the fungous disease mentioned in a previous chapter.

Hewitt states that in England it is often found in houses, and he himself has found it in large numbers in the windows of a country house in March and April. He states that it is popularly known in England as the "storm fly" from its habit of seeking the shelter of houses during wet weather.

Newstead states that in England (and the same conditions hold for this country) farm yards and stables are the favorite haunts of this fly, but that it occurs also in the fields and parks and open woods, especially where cattle are grazing. He has seen it resting on the shop fronts of the main streets of both Liverpool and Chester, and states that it is fond of resting on surfaces fully exposed to the sun and that painted surfaces are also attractive to it. The greatest number he ever saw congregated together was on the sunny side of a red-painted iron tank at the old Château de Goumont, Waterloo, Belgium. At night, he states, they retire to some sheltered spot, and numbers may be found at rest on the beams and rafters in open sheds

at farm yards, where they remain until the morning sun tempts them out.

Both males and females suck blood. According to Osborn, while this fly inflicts a deep bite it does not gorge itself at a single animal, but may fly from one to another in securing a meal. From this fact he thinks the idea that this fly is apt to be a transmitter of glanders from diseased to healthy horses, and anthrax among cattle, receives important support. The puncture under ordinary circumstances does not seem to be poisonous to men, and aside from the pain given it is less dangerous than a mosquito bite. Newstead noticed a female drive its proboscis into the thorax of a dead companion and apparently suck up the juices of its body. The same writer permitted one to suck blood from his hand and observed it carefully during the process. The insect sat high on its legs, the whole of the proboscis was straightened and held vertically, and the lower third was driven into the flesh. During the process, which lasted fifteen minutes, the proboscis was constantly but somewhat slowly moved up and down, and also with an occasional semi-rotary movement, like the action of a quarryman's hand drill. There was no subsequent irritation or soreness of any kind. The fly died twelve hours after feeding. During other observations Newstead found that the flies lived for several days in captivity, and that the females died either immediately or shortly after laying their eggs.

The biting house fly has almost as wide a geographic distribution as the true house fly. It was probably orig-

inally an European species and has spread by the help of commerce to many parts of the world. It occurs all over North America and is also to be found in Central and South America. It is also found in Australia, China, India, and the Canary Islands.

The writer has reared the biting house fly from cow manure and from horse manure. I judge from the fact that it is attracted to human excreta that it may become a carrier of intestinal disease. It has been reared from sheep's dung and from warm decaying vegetable refuse, especially from piles of fermenting lawn grass.

Lucien Iches, in the Bulletin de la Société Nationale d'Acclimatation de France, March, 1909, published a very interesting article on *Stomoxys calcitrans* and Argentine cattle, giving the results of a brief investigation made by him in 1908 in the province of Santa Fé, Argentina. The biting flies swarmed on a large estate in almost incredible numbers. The cattle were driven nearly crazy by them. Certain valuable Durham bulls which were observed were covered with the flies. They had lost their hair in large spots and the skin was cracking.

Monsieur Iches naturally sought at once for the principal breeding places of the flies, and found them to be in the stacks of debris from the threshing of wheat and flax. Larvæ and puparia were found by the millions in the lower portions of these piles of straw, where some fermentation had already begun. The sensible measure which he recommended was to have this de-

bris burned within forty-eight hours after the completion of the threshing, the ashes being used for fertilizing purposes. It turned out that there was an old provincial law in the province of Santa Fé ordering the burning of the debris after threshing, but it had not been carried out during recent years, and therefore the Stomoxys multiplied until this veritable plague ensued. In 1888 this Stomoxys made its appearance in extraordinary numbers near Salem, Oregon, and it is altogether likely that there was some similar reason for its extraordinary abundance that year. At that time, however, its true breeding places were not known and the cause of the outbreak was not found.

There are undoubtedly many substances in which the biting house fly breeds, and it evidently requires about the same conditions as does the true house fly.

The larvæ and puparia of this species have been figured by the writer, but the full life history has been carefully studied by Newstead. He found that the eggs are laid in an irregular heap and that the average number deposited is about sixty. The egg is much like that of the house fly, and is one millimeter long. It hatches in from two to three days in an average temperature of 72° F. in the day and 65° F. in the night. The larva need not be described, since it is similar to that of the house fly. Newstead found that in this stage they lived from fourteen to twenty-one days, but that the absence of excessive moisture and the admission of a little light materially retarded development, which then extended over a period of thirty-one to seventy-

eight days. In the puparium the insect remained from nine to thirteen days. The development of the species is therefore slower than that of the true house fly. It is Newstead's opinion that the winter is passed chiefly in the pupal condition. Packard (1874) describes the pupa of this species.

The extraordinary effects of numbers of the bites of this fly, indicated in the account of the epidemic of 1908 in Argentina, cannot be exaggerated. Cattle and horses suffer severely from these bites when the insects are numerous. Mr. T. J. Bold, in the *Entomologists' Monthly Magazine* for 1865, p. 143, gives an account of the condition of these animals at Long Benton in September of that year. Fourteen cows were under treatment by a veterinary surgeon at one time. The animals were generally bitten on the outside of the legs, on the shoulders, and, rarely, on the neck. In severe cases the joints were so much swollen that the animals could not bend their legs to lie down, and the swelling from the inflammation was so great that the outer skin cracked and the hair fell off. It is stated that the flies appeared to prefer the knees and upper portion of the foot of the cow, frequently crawling from them to the hands of the veterinary, but their bites had no bad effect on him. It would seem from this as though animals are more susceptible than man.

This biting fly has often been thought to be a disease carrier and especially of blood parasites of domestic animals. The evidence for and against has been carefully considered by Austen (1909, p. 153), who

summarizes his conclusions in the following words: "It may be regarded as proved that *Stomoxys calcitrans* L., as also *S. nigra,* Macq., and probably other species of the genus, can convey trypanosomes directly from an infected to a healthy animal, when the bites follow one another immediately. On the other hand, the evidence tends to show that when the interval between the bites is longer (the maximum period within which a bite is infectious has not yet been determined), although active trypanosomes may be present in the intestine of the fly, its life is innocuous. There is no indication that trypanosomes ingested by *S. calcitrans* pass through a developmental cycle, and they apparently disappear within twenty-four hours. With regard to diseases other than trypanosomiases, there are some grounds for thinking that *S. calcitrans,* like other biting flies, may occasionally disseminate the bacillus of anthrax, and, in Europe, it would appear that the fly is the intermediate host of a species of *Filaria* parasitic in cattle.

The Little House Fly
(*Fannia* [*Homalomyia*] *canicularis* L.)

In discussing the size of the adult house fly in Chapter I, we mentioned this little fly which is found rather commonly upon window-panes in houses, and stated that it was the source of the prevalent error to the effect that house flies grow after they become winged and that these little flies are the young of the larger flies. They belong, however, not only to an entirely

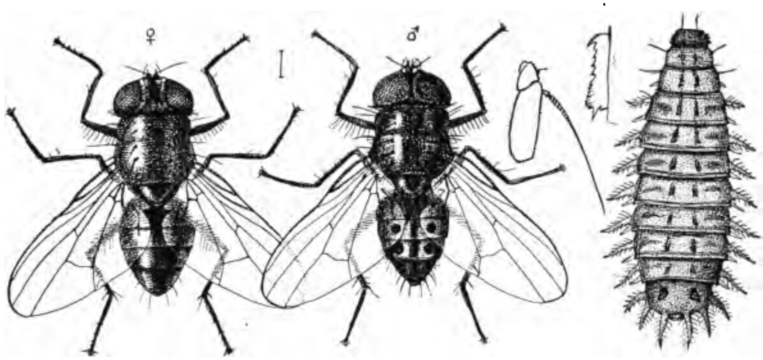

Fig. 24.—The little house fly (*Homalomyia brevis*) ; antennæ and larva at right; greatly enlarged. (Author's illustration.)

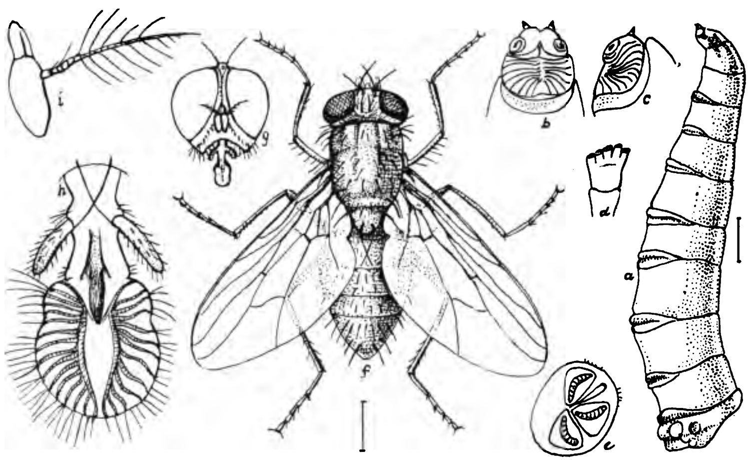

Fig. 25.—The stable fly (*Muscina stabulans*) ; larva at right; greatly enlarged. Anatomical details *b, c, d, e, g, h, i,* still more enlarged. (Author's illustration.)

distinct species but to a different family, these little ones being members of the family Anthomyidæ. There are several of these species of Homalomyia, including not only *canicularis,* but *H. brevis* Rond. and *H. scalaris* Fab., but *canicularis* is the one found most abundantly in houses. The name "little house fly" has not been definitely applied to it in this country, but it is a translation of the German popular name, "Kleine Stubenfliege." The larvæ of this species live in decaying vegetable material and have also been found living in dead insects of different kinds. They have even been found in the nests of the common bumblebee. They will breed also in excreta of animals and in human excreta, and therefore would be quite as dangerous as the true house fly were they as numerous. They make their appearance early in the summer and persist until autumn.

The allied species, *H. brevis,* is not so common in houses as the one just mentioned, but it is an abundant breeder in human excrement.

Both species are rapid breeders, and a generation is produced every two weeks, in the vicinity of Washington, in summer. The full development has not been traced, but the larvæ are quite different from the larvæ of the house fly. That of *brevis* is shown in Fig. 24. It and its relatives are all furnished with a double row of spiny processes on either side, giving them a very characteristic appearance. Their larvæ have occasionally been found in freshly passed human dejecta and are surely on occasion voided by persons who have

probably swallowed them with uncooked vegetable food.

The Stable Fly (*Muscina stabulans* Fall.)

This is one of the flies which very much resemble the house fly, and is frequently mistaken for it. It belongs to the same family and is of the same general color. It is not so abundant in houses as some of the others we have mentioned. In 1900, out of the 23,087 flies collected in dining-rooms and kitchens in different parts of the country, thirty-seven belonged to this species. It is common throughout Europe, everywhere in the United States, and extends south to Argentina. In England it is said to be found in and near houses. Hewitt has found it occurring in early summer before the house fly has appeared in great numbers. It is somewhat larger than the true house fly, and is well shown in the accompanying figure, which also shows some of the structural details of both the adult and the larva. The adult may be at once distinguished from the house fly by the gradual curve of the vein reaching the tip of the wing, instead of the abrupt angle in the same vein in the house fly.

The larvæ of the stable fly live upon decaying substances, fungi, etc., but it is recorded in Europe as feeding upon caterpillars and larval bees. Schiner states that it breeds in cow dung, and it has also been found in dead animals. In this country it feeds upon the dead chrysalids of insects, and has been reared from dying squash plants. The fly has also been reared from

masses of the larvæ and pupæ of the imported elm leaf beetle; also from a decaying squash. Aldrich in Idaho has reared it from rotting radishes. In Washington it has been reared from human excreta. The complete round of a generation is said to occupy from five to six weeks. (Fig. 25.)

This fly is one of the dangerous occasional inhabitants of houses, not only because it may breed in human excreta, but because it is greatly attracted to this substance when it chances to be deposited in the open. There seems to be no especial reason why it should be called the stable fly, since the preferred food habits of its larvæ should make it more abundant away from stables, and its scientific name *stabulans* was given to it by Fallen before its real habits were known.

It is interesting to note, by the way, that the larva of the fly has been found to have passed through the human stomach, to which it had probably gained entrance through the eating of spoiled vegetables.

THE CHEESE FLY (*Piophila casei* L.)

The little, shining-black flies of the genus Piophila breed in cheese, ham, chipped beef, and other fatty or spoiled and decaying animal matter. The eggs hatch into small, white, cylindrical maggots which feed upon the cheese or meat and rapidly reach full growth, at which time they are one-half of an inch in length. The maggot is commonly called the cheese skipper or the ham skipper from its wonderful leaping powers, which it possesses in common with certain other fly larvæ, all

of which lack legs. The leap is made by bringing the two ends of the body together and suddenly releasing them, like a spring. In this way it will sometimes jump three or four inches. The species is cosmopolitan at present, and it was doubtless originally imported from Europe into the United States in old cheeses.

Careful observations have been made on the life history of this fly by several writers. In 1892 Miss Mary E. Murtfeldt studied the life history of the summer generation in a western packing establishment. She found that the eggs were laid in rather close clusters of from five to fifteen, and were also deposited singly. About thirty seem to have been laid by a single female. The egg is white, slender, oblong, slightly curved, one millimeter in length, and with a diameter about one-fourth of its length. It hatches in about thirty-six hours, and the larva completes its growth in from seven to eight days, reaching a length of seven to nine millimeters. Where food is sufficient the larva does not move about, and groups of them will sometimes complete their growth in the same crevice in which the mother fly deposited her eggs. When full grown, however, the larva moves away to some dry spot, contracts in length, assumes a yellowish color, and gradually forms into a golden-brown puparium four or five millimeters in length. The adult fly issues in ten days. Thus three weeks may complete the entire life cycle, in August, in St. Louis.

In Europe, Kessler found that the average summer duration of this insect is four to five weeks, and states

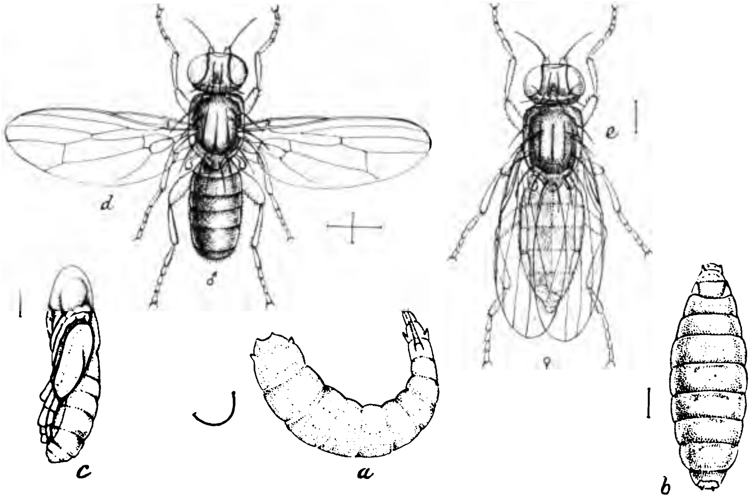

Fig. 26.—The cheese fly (*Piophila casei*) : *a*, larva ; *b*, puparium ; *c*, pupa ; *d*, adult male ; *e*, adult female ; all enlarged. (Author's illustration.)

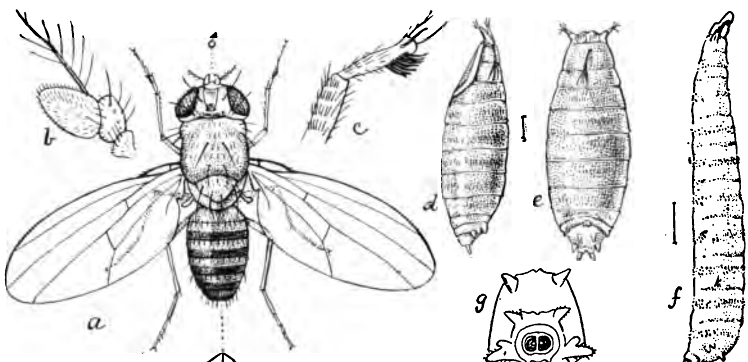

Fig. 27.—The fruit fly (*Drosophila ampelophila*) ; *a*, adult male ; *b*, antennæ ; *c*, fore tibia ; *d*, *e*, puparium ; *f*, larva ; *g*, anal segment of larva ; enlarged. (Author's illustration.)

that the larva over-winters in the puparium. Other writers say that the insect passes the winter as an adult fly. (Fig. 26.)

In this country this fly does not play so important a part as a cheese insect as it does as an enemy to smoked meat. It seems certain that the mother fly prefers the older and richer cheeses in which to deposit her eggs. Her taste is excellent, and, while it is a fair thing to say that skippery cheese is usually the best, it will hardly do to support the conclusion that it is good because it is skippery, although this conclusion is current among a certain class of cheese eaters.

The cheese fly, under ordinary circumstances, is not a dangerous species, but it is well to remember that not only has it been reared from dead bodies, but that it is also attracted to excreta of all kinds.

THE FRUIT FLIES (*Drosophila ampelophila* Loew)

The minute flies of the family Drosophilidæ, commonly known as fruit flies or pomace flies, are attracted to decaying vegetation, especially to fruit, and are frequently found in houses in the autumn about dishes containing pears, peaches, and grapes. They are attracted to fruit both for food and for places to lay their eggs, since their larvæ live in decaying vegetable matter.

The commonest of the fruit flies in the United States is *Drosophila ampelophila*. It occurs also in the West Indies and South Europe. It does considerable damage to canned fruits and pickles, breeds in decaying

apples and the refuse of cider mills and fermenting vats of grape pomace. It is a rather rapid breeder, and a generation may develop in twenty days, more or less. It is attracted especially to preserves and canned goods, and frequently damages raspberry vinegar. It is often very difficult to prevent the fly from entering fruit jars.

There are about thirty species of Drosophila in North America, and the majority of them breed in the juices of decaying and fermenting fruit. Aside from the one just mentioned, *D. amœna, D. funebris, D. graminum,* and *D. transversa* are occasionally found in houses. Another species, *D. cellaris,* occurs in cellars in fermenting liquids, such as wine, cider, vinegar, and beer; also in decaying potatoes. Another species damages flour paste; and still another mustard pickles. One species, *D. flaveola,* does not need decaying vegetation for its larval food, since its larvæ mine the leaves of cabbages and radishes.

The fruit flies may be dangerous inhabitants of houses, since they are nearly all attracted to excreta, and some of them breed in human excrement. The larva and puparium, as well as the adult fly of *D. ampelophila,* are shown in Fig. 27.

The Bluebottle or Greenbottle Flies

The Blow Flies (*Calliphora erythrocephala* Meig., *Lucilia cæsar* L., *Phormia terrænovæ* Desv.)

Several species of bluebottle or greenbottle flies occasionally gain entrance to houses, and all are danger-

ous species and liable to carry intestinal diseases. Their larvæ as a rule feed in excreta or in decaying flesh, but a bluebottle fly in a milk jug is no more dangerous than a house fly in the same situation.

Lucilia cæsar L. (Fig. 28) is a common and widespread form, abundant in both Europe and North America, and is one of several species of the shining green or bluish flies commonly found about dead animals and different kinds of excreta. It is not ordinarily found in houses, but may be driven in at the approach of a heavy storm, just as is the case with the biting house fly. On May 17, 1899, for example, a heavy storm occurred about four P.M., and the next morning twenty-eight specimens of this species were found to have come into one of the rooms of my office. In Europe *L. cæsar* is known as the "greenbottle fly," and is almost exclusively a carrion feeder.

Calliphora erythrocephala Meig. (Fig. 29) is another widespread species common to Europe and North America. It is a large bluebottle fly of rather dull color with black spines on the thorax. It is the common blow fly of Europe and is the species treated by Lowne in his classic work on the anatomy of the blow fly. Its larvæ are indistinguishable from those of the greenbottle fly. The eggs are laid on meat and dead animals and even upon dead insects. The species is unusual from the enormous number of eggs laid by a single female. The Russian author, Porchinsky, records from 450 to 600 eggs from a single female. Hewitt records the duration of a single generation as

from twenty-two to twenty-three days. This blow fly is a characteristically out-of-door fly, but under certain circumstances may be found in houses in some numbers. In October, 1899, for example, a gentleman living in the suburbs of Washington found thousands of these flies in his cellar. No cows or horses were kept near the house, and there had been no dead animals about so far as he knew. It is probable, however, that these flies had come from some dead animal, and had sought the cellar for hibernating purposes, although the weather was still warm.

Phormia terrænovæ Desv. (Fig. 30.) The bluebottle fly just mentioned is a rather large species. The Phormia, however, is a medium-sized or rather small bluebottle. It was originally described from Newfoundland, but is widespread in the United States. It is occasionally found in houses, and I have more than once seen them upon window panes. It is abundantly attracted to human excreta, and has been taken under many varying conditions about Washington: enormous numbers were found on one occasion in the sinks of a deserted militia camp at Leesburg, Virginia.

The Flesh Flies (*Sarcophaga assidua* Walk.)

We include under this heading the flies of the genus Sarcophaga, on account of the significance of the scientific name, although many Sarcophagids are not true flesh eaters. Several of them very closely resemble the house fly, and some of them are sometimes found in houses. The common widespread flesh fly of Europe

Fig. 28.—*Lucilia cæsar;* enlarged. (Author's illustration.)

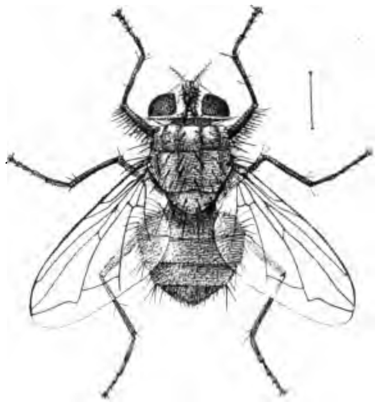

Fig. 29.—*Calliphora erythrocephala;* enlarged. (Author's illustration.)

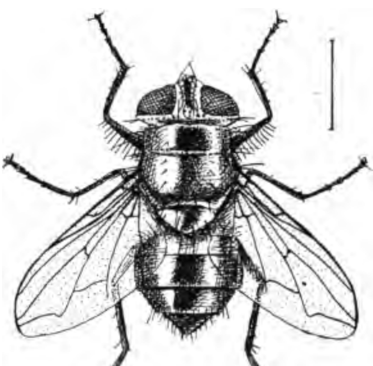

Fig. 30.—*Phormia terrænovæ;* enlarged. (Author's illustration.)

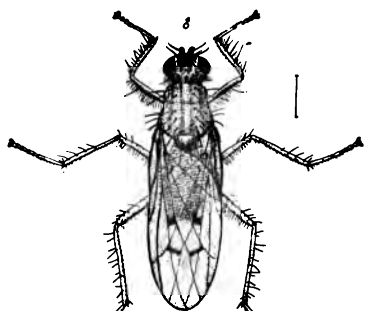

Fig. 33.—*Scatophaga furcata;* enlarged. (Author's illustration.)

and Australia, a very general scavenger, is known as *Sarcophaga carnaria* L., and in countries which it inhabits is once in a while found in houses. It does not seem to occur in the United States, although a species which much resembles it, *S. sarraceniæ* Riley, is abundant throughout the country. It looks like a very large and active house fly, and is occasionally found in houses. It is commonly reared from the remains of dead insects, but is also attracted to and breeds in excreta. (Fig. 31.)

A smaller species, *S. assidua* Walk., much resembles the house fly and is of about the same size. . It is confined to the United States and is occasionally found in houses. It, like the preceding species, breeds in dead insect remains, but is attracted to and breeds in excreta and is therefore dangerous.

The Dung Flies

(*Sepsis violacea* Meig., *Scatophaga furcata* Say)

There is a little black fly known as *Sepsis violacea* Meig., which is shown in Fig. 32 and which is not at all uncommon in houses, being found as a rule upon the window panes. It belongs to the same family as the cheese fly, but does not attack stored foods or anything to be found in the pantry. It breeds almost exclusively in excreta and has been reared in swarms from an old human deposit collected on the Potomac flats near the city of Washington. It is very small in size, glistening black in color, and of slender shape.

There is a whole family of small, brownish flies

known as the Scatophagidæ, which, as the scientific name indicates, are attracted to and breed in the dung of different animals, and also to some extent in decaying vegetable material. They are, as a rule, rather light-colored, bristly flies. The species shown at Fig. 33 is known as *Scatophaga furcata* Say. It is a North American species of rather wide distribution, which in its early stages lives in all sorts of excreta and is once in a great while found in houses. It does not hibernate as an adult fly, but in its puparia in dung.

The Moth Flies (*Psychoda minuta* Banks)

There are certain very minute flies belonging to a family known as the Psychodidæ, which are very peculiar from the fact that they resemble little moths, their broad wings being covered with hairs, making them look like moths. They are very weak fliers, and are frequently found upon windows and on the under surfaces of leaves. They are so small and fragile that they are difficult to capture and preserve. What they do in houses no one knows, unless possibly they enter them for protection. The larvæ of some species breed in excreta; others in decaying vegetation, and still others in water, sewage-polluted water being preferred. *Psychoda minuta* Banks has been reared from cow dung at Washington. None of the North American species has the blood-sucking habit, although a genus (Phlœbotomus) which occurs in Southern Europe and in other parts of the world bites human beings and has been accused of disease-carrying probabilities.

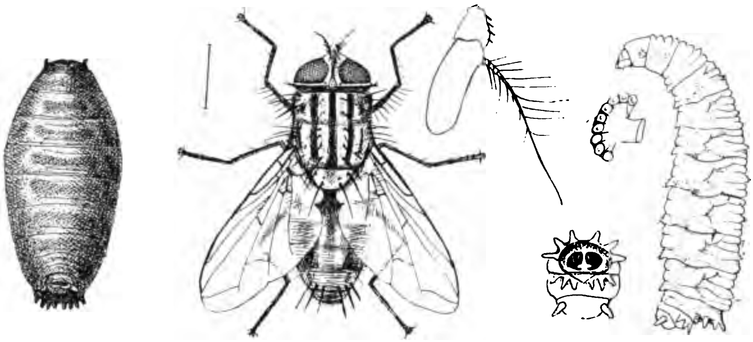

Fig. 31.—*Sarcophaga assidua;* larva at right, puparium at left; enlarged. (Author's illustration.)

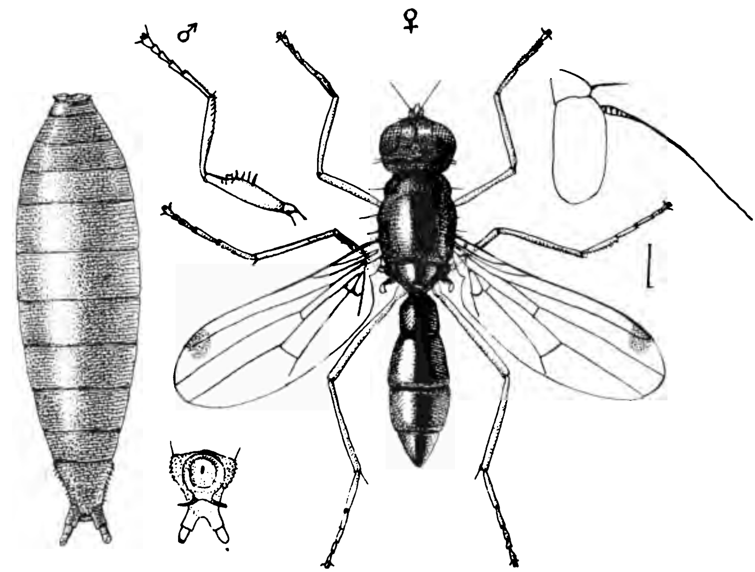

Fig. 32.—*Sepsis violacea;* puparium at left; enlarged antennæ at upper right; enlarged. (Author's illustration.)

The Humpback Flies

The humpback flies of the family Phoridæ need not be mentioned here especially, except for the fact that one of the species, *Hypocera* (*Phora*) *femorata,* occurs occasionally in houses, and possibly others of the family

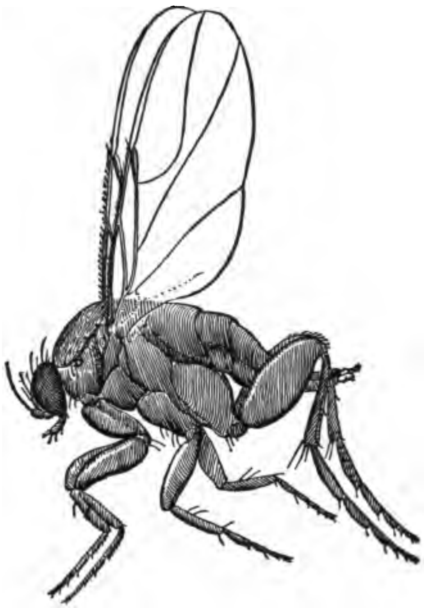

Fig. 34.—*Phora femorata;* greatly enlarged. (Original.)

may also be found from time to time in domiciles. In the collection of flies made in houses in 1900 there were thirty-three specimens of *P. femorata* out of the 23,087 flies captured. The larval habits of this par-

ticular species are not known, but its relatives feed in the earlier stages on decaying vegetable matter, dead insects, snails, etc. The species in question possibly fed upon decaying vegetation in the neighborhood of the houses in which it was collected.

THE WINDOW FLIES (*Scenopinus fenestralis* L.)

Comstock has applied the term *window flies* to the little flies of the family Scenopinidæ. The term, however, does not apply to all of them; but the best-known

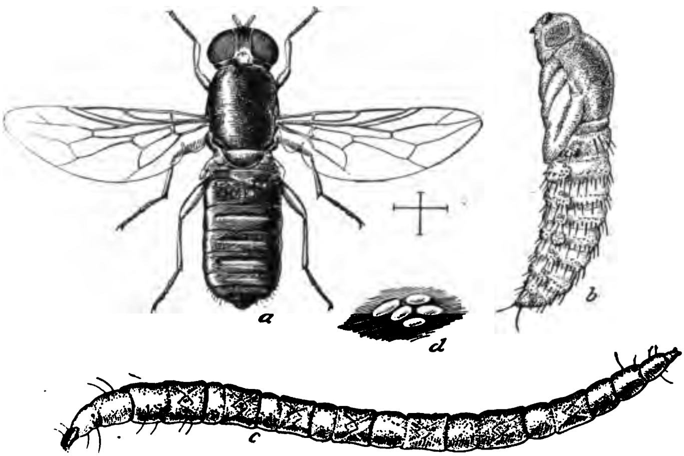

Fig. 35.—*Scenopinus fenestralis; a,* adult; *b,* pupa; *c,* larva; *d,* eggs; enlarged. (Original.)

species, namely, *Scenopinus fenestralis,* is not uncommonly found upon windows both in this country and in Europe. These flies are usually black and rather smooth, *S. fenestralis* being about one quarter of an

inch long. It has a humpbacked appearance, and the abdomen is flattened. Osten Sacken (1886) has given a good review of the European literature on the habits of this fly, and has shown that it has been reared from decaying tree fungi, from horse hair in a mattress, from a swallow's nest, from the cocoon of a large moth, from carpets, from a branch of a tree, from pine boards, from the pupa of a large moth, and from a root of aconite.

The different European authors making these observations from time to time have thought variously that the window fly was carnivorous or vegetarian, in accordance with the substances from which they reared it. Osten Sacken, however, concludes rather positively that it is carnivorous, that the larva does not frequent fungi, rotten wood, swallows' nests, etc., for the sake of vegetable material or animal remains, but for the sake of the pupæ and perhaps also of the larvæ which it finds there. He deduces from this that when it occurs in carpets and horse hair, it is not because it feeds on them, but because it hunts there for the larvæ and pupæ of the moths or other insects that live in them.

Similarly in this country divers observations have been made, and the records of the Bureau of Entomology at Washington show that it has been reared from strawberry plants, from the egg-pods of grasshoppers, from the hair of a Navajo blanket, from a sack of rye infested with the grain beetle, from under carpets, among stored oats and stored corn, from a basket containing small rolls of cotton and woolen goods, and

from the seeds of sugar beets stored in a mill; also from larvæ found with other larvæ on the roots of roses, as well as from under the bark of a post-oak pole. Exact observations have been made here showing that the larva is undoubtedly carnivorous: it has been fed upon the larvæ of stored grain insects, and when found in woolen goods and under carpets it is undoubtedly in search of clothes moths upon which to feed.

The larva is long, white, and snake-like in shape, with a dark head. It apparently has many segments to the body, since each of the abdominal segments is divided by a strong constriction. In feed stores the flies are nearly always to be found around the windows, and the probability is very strong that they feed upon such small soft-bodied creatures as flour mites and beetle larvæ.

Nothing definite has been ascertained concerning the duration of the different stages, but from larvæ taken in January adults issued in April, and from larvæ received April 18th adults issued on the 9th of June; with larvæ received August 6th, one changed to pupa on August 25th, another on August 29th, the flies issuing September 10th and 12th respectively.

It is a pleasure to state that at least one of the flies found in houses is probably beneficial rather than injurious, and that this species is *Scenopinus fenestralis*.

BIBLIOGRAPHICAL LIST

AINSWORTH, R. B. (1909). The house fly as a disease carrier. *Journal of the Royal Medical Corps,* xii, No. 5, May, 1909, 485-491.

ALDRICH, J. M. (1905). A Catalogue of North American Diptera. Smithsonian Misc. Coll., XLVII, pp. 680.

ALDRIDGE, A. R. (1907). House flies as carriers of enteric infection. *Journ. Royal Army Medical Corps,* ix, 558.

AUSTEN, E. E. (1904). The house fly and certain allied species as disseminators of enteric fever amongst troops in the field. *Journ. Royal Army Med. Corps,* ii, 651-668, 2 plates.

AUSTEN, E. E. (1906). Illustrations of British biting flies, with notes. British Museum of Natural History, pp. 74, plates 34.

AUSTEN, E. E. (1909). Notes on the examination of batches of flies received from various centers in London during the summer and autumn of 1908. *Repts. to the Local Govt. B'd on Public Health and Medical Subjects.* London. N. S., No. 5, 4 tables, 1 pl.

AUSTEN, E. E. (1909). Illustrations of African blood-sucking flies other than mosquitoes and tsetse-flies. London. British Museum of Natural History, pp. 221, 13 plates. (Account of Stomoxys calcitrans, pp. 142-153.)

BERNSTEIN, J. (1910). Summary of the literature relating to the bionomics of the parasitic fungus of flies. *Repts. to the Local Govt. B'd on Public Health and Medical Subjects.* London. N. S., No. 40, 41-45.

BEZZI, M., and STEIN, P. (1907). *Kat. d. Palaearktischen Dipt.* von Th. Becker, M. Bezzi, Kertész u. P. Stein, III (*Cyclorrapha Aschiza*). Budapest.

BRAUN (1882). (Ophthalmia.) *Centralbl. f. prakt. Augenheilk.*, p. 545.

BUCHANAN, R. M. (1907). The carriage of infection by flies. *Lancet*, II, 216-218, 5 figs.

BUCHANAN, W. T. (1897). Cholera diffusion and flies. *Indian Medical Gazette*, 86-97.

BUDD, W. (1862). Observations on the occurrence (hitherto unnoticed) of malignant pustule in England. *Lancet*, II, 164-165.

CARTER, H. J. (1861). On a bisexual nematode worm which infests the common house fly in Bombay. *Ann. Mag. Nat. Hist.*, Ser. 3, VII, 29-33, 4 figs.

CASTELLANI, A. (1907). Experimental investigations on Frambœsia tropica (Yaws). *Journ. of Hygiene*, VII, 558-569, 2 pl., 1 fig.

CELLI, A. (1888). Transmissibilità dei germi patogeni mediante le dejecione delle mosche. *Bull. d. Soc. Lanci. d. ospedali di Roma*, f. 1, p. 1.

CHANTEMESSE (1905). (Cholera and flies.) Report of meeting of Acad. Med., Paris, reviewed in *Med. Record*, LXVIII, 989.

COBB, J. O. (1905). Is the common house fly a factor in the spread of tuberculosis? *American Medicine*, IX, 475-477.

COBB, N. A. (1906). Fungous maladies of the sugar cane. *Bull. 5, Experiment Station, Hawaiian Sugar Planters' Association, Division of Pathology.* Honolulu.

COBB, N. A. (1910). The house fly. *National Geographic Magazine*, May, 1910, 371-380, 4 figs.

COPEMAN, S. M. (1906). Report . . . County Borough of Wigan, p. 18.

DAVAINE, C. (1870). Études sur la contagion chez les animaux domestiques. *Bull. de l'Academie de Med.* Paris, XXXV, 215-235.

DEMETRIADES (1894). (Ophthalmia). *Centralblatt f. prakt. Augenheilk.*, p. 412.

DICKINSON, G. K. (1907). The house fly and its connection with disease dissemination. *Medical Record,* LXXI, 1907, 134-139.

DUTTON, W. F. (1909). Insect carriers of typhoid fever. *Journ. Am. Med. Assoc.*, LIII, 1248-1252, 7 figs.

ESTEN, W. M., and MASON, C. J. (1908). Sources of bacteria in milk. *Bull. 51, Storrs Agric. Experiment Station.* (Flies, pp. 94-98.)

FAICHNIE, N. (1909). Fly born enteric fever and source of infection. *Journ. Roy. Army Med. Corps,* XIII, Nov., 580-584.

FAICHNIE, N. (1909). *Journ. Roy. Army Medical Corps,* 602-605.

FELT, E. P. (1909). The economic status of the house fly. *Journ. Economic Entomology,* II, 39-45 (Discussion).

FELT, E. P. (1909). The typhoid or house fly and disease. *24th Rept. State Entomologist of N. Y.*, 24-40 (Good bibliographical list).

FELT, E. P. (1910). Control of flies and other household insects. *N. Y. State Museum Bulletin 136.*

FICKER, M. (1903). Typhus und Fliegen. *Arch. f. Hygiene,* XLVI, 274-283.

FIRTH, R. H., and HORROCKS, W. H. An inquiry into the influence of soil, fabrics and flies in the dissemination of enteric infection. *Brit. Med. Journ.*, 20 pp. reprint.

FROGGATT, W. W. (1910). The house fly and the diseases it spreads. *Agric. Gazette, New South Wales,* March. 8 pp., 1 fig.

GALLI-VALERIO, B. (1910). L'état actuel de nos connaissances sur le role des mouches dans la dissemination des maladies parasitaires et sur les moyens de lutte à employer contre elles. *Centralbl. f. Bakteriologie,* LIV, Heft 3, 193-209.

GANON. (1908). Cholera and flies. *Geneesk, Tijdschr. v. Nederl. Indie,* XLVIII, 2. Quoted in *Journ. Trop. Med. and Hyg.,* May 15, 1909.

GERMAN. (1896). (Ophthalmia). *Centralbl. f. prakt. Augenheilk.* Suppl. p. 386.

VON GLEICHEN, FREIHERR FRIEDRICH WILHELM (Genannt Russworm) (1764). "Geschichte der gemeinen Stubenfliege"; Herausgeben von J. C. Keller, Nürnberg, 4 pl, 34 pp.

GODFREY, R. (1909). The false-scorpions of Scotland. *Ann. Scot. Nat. Hist.,* 22-26.

GRAHAM-SMITH, G. S. (1909). Preliminary note on examinations of flies for the presence of colon bacilli. *Repts. to the Local Gov't B'd on Public Health and Medical Subjects.* London. N. S. No. 16, 9-13.

GRAHAM-SMITH, G. S. (1910). Observations on the ways in which artificially-infected flies (*Musca domestica*) carry and distribute pathogenic and other bacteria. *Repts. to the Local Gov't B'd on Public Health and Medical Subjects.* London. N. S. No. 40, 1-41, 8 pl.

GRIFFITH, A. (1908). Life history of house flies. *Public Health,* XXI, 122-127.

GUYÉNOT, E. (1907). L'appareil digestif et la digestion de quelques larves des mouches. *Bull. scientif. de la France et de la Belgique,* XLI, 353-369.

HAMER, W. H. (1908). Nuisance from flies. *Report of Public Health Com. London County Council,* No. 1138.

HAMILTON, A. (1903). *Journ. Am. Med. Assoc.* Febr. 27.

HAMILTON, A. (1906). The rôle of the house fly and other insects in the spread of infectious disease. *Ill. Med. Journal.* Springfield. IX, 583-587.

HAYWARD, E. H. (1904). The fly as a carrier of tuberculous infection. *New York Med. Journ.*, LXXX, 643-644.

HERMES, W. B. (1910). How to control the common house fly. *Monthly Bull. Cal. State B'd of Health,* V, II, May, 1910, 269-277, 5 figs.

HERVIEUX (1904). Report on carriage of smallpox by flies, read to the Academy of Medicine, Paris, June 5, 1904. *Lancet,* I, 1761.

HEWITT, C. GORDON (1910). The house fly; a study of its structure, development, bionomics and economy. *Manchester, Eng., the University Press.* (About 200 pp., many plates.)

HEWITT, C. GORDON (1910). House flies and their allies. *Fourth Ann. Rept. Entomological Society of Ontario,* 30-36.

HEWITT, C. GORDON (1910). House flies and disease. *Nature,* 84, July 21, 73-75, 2 figs.

HIRSCH, C. T. W. (1896). An account of two cases of coko or frambœsia. *Lancet,* II, 173-175.

HODGE, C. F. (1910). A practical point in the study of the typhoid or filth fly. *Nature Study Review,* VI, No. 7, 195-199.

HOWARD, L. O. (1896). The cheese skipper. *Bull. 4, n. s., Division of Entomology, U. S. Dept. Agric.,* 102-104, 1 fig.

HOWARD, L. O. (1896). The fruit flies or vinegar flies. *Bull. 4, n. s., Division of Entomology, U. S. Dept. Agric.,* 109-111, 1 fig.

HOWARD, L. O. (1896). House flies. (The principal household insects of the United States. L. O. Howard and C. L. Marlatt.) *Division of Entomology. U. S. Dept. Agric., Bull. 4, n. s.,* 43-47.

HOWARD, L. O. (1898). House flies. *Circular 35, Division of Entomology, U. S. Dept. Agric.*, pp. 8, figs. 6.

HOWARD, L. O. (1898). Further notes on the house fly. *Bulletin 10, n. s., Division of Entomology, U. S. Department Agric.*, 63-65.

HOWARD, L. O. (1900). A contribution to the study of the insect fauna of human excrement. (With especial reference to the spread of typhoid fever by flies.) *Proc. Washington Acad. Sci.*, II, 541-604, pls. XXX-XXXI, 38 figs.

HOWARD, L. O. (1901). On some Diptera reared from cow manure. *Canadian Entomologist*, Febr., 42-44.

HOWARD, L. O. (1902). How insects affect health in rural districts. *Farmers' Bulletin 155, U. S. Dept. Agric.*, pp. 19, figs. 16. Revised edition, 1908.

HOWARD, L. O. (1906). House flies. *Circular 71, Bureau of Entomology, U. S. Dept. Agric.*, pp. 9, figs. 9. (Revision of Circular 35, 1898.)

HOWARD, L. O. (1909). Economic loss to the people of the United States through insects that carry disease. *Bull. 78, Bureau of Entomology, U. S. Dept. Agric.*, 23-36 and 7.

JACKSON, D. D. (1907). Pollution of New York Harbor as a menace to health by the dissemination of intestinal diseases through the agency of the common house fly. pp. 22. *New York, published by the Merchants Association.*

JEPSON, J. P. (1909). Some observations on the breeding of *Musca domestica* during the winter months. *Repts. to the Local Gov't B'd on Public Health and Medical Subjects.* London. N. S., No. 5, 5-8. Also *Journ. Econ. Biol.*, IV, 3, 78-82.

JEPSON, J. P. (1909). Notes on experiments in coloring flies, for purposes of identification. *Reports to the*

Local Gov't B'd on Public Health and Medical Subjects. London. N. S., No. 16, 4-9.

JONES, F. W. C. (1907). Notes on enteric fever prevention in India. *Journ. Royal Army Med. Corps,* VIII, 22-34.

JOSEPH, G. (1887). Über Fliegen als Schädlinge und Parasiten des Menschen. Theil IV, Myiasis sceptica. *Deutsche Medicinal-Zeitung,* No. 65, 725-728.

KELLERS, H. C. (1911). A sanitary garbage-can holder. *U. S. Naval Med. Bull.,* V, 1, 45.

KOBER, G. M. (1892). The etiology and prevention of infectious diseases. Reprinted from *Va. Med. Monthly,* April. (Calls attention to observations of Celli, Spillman and Hoffman.)

KOBER, G. M. (1905). Report on the prevalence of typhoid in the District of Columbia. *Rept. of the Health Officer* (D. C. for the year ending June 30), pp. 253-292.

LAVERAN, A. (1880). Contribution a l'étude du bouton de Biskra. *Ann. de Dermatologie,* 2 S. I, 173-197.

LEDINGHAM, J. C. G. (1910). Report to the Local Government Board on the enteric fever carrier. 138 pp. Wyman and Sons. (Review in *Nature,* Dec. 1.)

LEIDY, J. (1871). Flies as a means of communicating contagious diseases. *Proc. Acad. Nat. Sci. Phila.,* 297.

LEVY, E. C., and FREEMAN, A. W. (1908). Certain conclusions concerning typhoid fever in the South, as deduced from a study of typhoid fever in Richmond, Va. Reprinted from *Old Dominion Journ. of Med. and Surg.,* VII, 5, Nov., 39 pp., 3 maps, 3 charts.

LORD, F. T. (1904). Flies and tuberculosis. *Boston Medical and Surgical Journal,* CLI, 24, 651-654.

LUBBOCK, SIR J. (1871). The fly in its sanitary aspect. *Lancet,* p. 270.

LUMSDEN, L. L., ROBERTS, N., and STILES, C. W. (1910). Preliminary note on a simple and inexpensive apparatus for use in safe disposal of night-soil. *Public Health Reports* (U. S. Public Health and Marine-Hospital Service), No. 54. Reprint, pp. 7, 1 fig.

MACLOSKIE, G. (1880). The proboscis of the house fly. *Amer. Nat.*, V, 153-161.

MACRAE, R. (1894). Flies and cholera diffusion. *Indian Medical Gazette*, XXIX, 407-415.

MADDOX, R. L. (1885). Experiments on feeding some insects with the curved or "comma" bacillus, and also with another bacillus (subtilis?). *Journ. Roy. Micros. Soc.*, ser. 2, V, 602-607, 941-952.

MANNING, J. (1902). A preliminary report on the transmission of pathogenic germs by the common house fly. *Journ. Am. Med. Assoc.*, May 17.

MARLATT, C. L. (1894). The house centipede. *Bull. 4, n. s., Division of Entomology, U. S. Dept. Agric.*, 47-50, 2 figs.

MATIGNON (1898). *Ann. d'Hygiene*, p. 237.

MORGAN, J. C., and HARVEY, D. (1909). An experimental research on the viability of the *Bacillus typhosus* as excreted under natural conditions by the "chronic carrier." *Journ. Roy. Med. Corps*, XII, 587-598.

MOORE, SIR W. (1853). Diseases probably caused by flies. *Brit. Med. Journ.*, I, 1154.

NASH, J. T. C. (1903). The seasonal incidence of typhoid fever and of diarrhœa. *Trans. Epidemiol. Soc.* London. N. S., XXII, 110-138.

NEWSHOLME, A. (1903). *Ann. Rept. on the health of Brighton* for 1903. p. 21 (Fly infection of milk).

NEWSTEAD, R. (1906). On the life-history of *Stomoxys calcitrans L. Journ. Econ. Biol.*, I, 4, 158-166, 2 plates.

NEWSTEAD, R. (1907). Preliminary report on the habits, life-cycle and breeding places of the common house

fly as observed in the city of Liverpool, with suggestions as to the best means for checking its increase. Liverpool, C. Tinling & Co. Ltd., 23 pp., 14 figs.

NEWSTEAD, R. (1909). Second ad interim report on the house fly. (Same publishers.) 4 pp.

NICHOLAS, G. E. (1873). The fly in its sanitary aspect. *Lancet,* II, 724.

NUTTALL, G. H. F. (1897). Zur Aufklärung der Rolle, welche Insekten bei der Verbreitung der Pest spielen. Ueber die Empfindlichkeit verschiedener Thiere für dieselbe. *Centralbl. f. Bakteriol.,* XXII, 87-97.

NUTTALL, G. H. F. (1900). On the role of insects, Arachnids and Myriapods as carriers in the spread of bacterial and parasitic diseases of man and animals. A critical and historical study. *Johns Hopkins Hospital Reports,* I, 1899-1900, 1-152.

NUTTALL, G. H. F., and JEPSON, F. P. (1909). The part played by *Musca domestica* and allied (non-biting) flies in the spread of infective diseases. *Reports to the Local Gov't B'd on Public Health and Medical Subjects.* London. N. S., No. 16, 13-41.

ODLUM, W. H. (1908). Are flies the cause of enteric fever? *Journ. Roy. Army Med. Corps,* X, 528-530.

ORTON, SAMUEL T. (1910). Experiments on the transmission of bacteria by flies with especial relation to an epidemic of bacillary dysentery at the Worcester State Hospital. *Boston Medical and Surgical Journal,* Dec. 8.

OSMOND, A. E. (1909). The fly—an etiological factor in intestinal disease, pp. 7, 1 chart. Reprinted from *The Lancet-Clinic,* April 10.

OSTEN SACKEN, C. R. (1886). Notes toward the life-history of *Scenopinus fenestralis. Entom. Monthly Mag.,* XXIII, 51-52.

PACKARD, A. S., JR. (1874). On the transformations of the common house fly. *Proc. Bost. Soc. Nat. Hist.*, XVII, 136-150.

PARROTT, P. J. (1900). To rid the house of flies. *Bull. 99, Kansas State Experiment Station*, Oct., 1900.

PATTON, W. S. (1909). The parasite of kala azar and allied organisms. *Lancet*, Jan. 30, 306-9, 2 figs.

PROWAZEK, S. (1904). Die Entwicklung von Herpetemonas einem mit den Trypanosomen verwandten Flagellaten. *Arb. aus dem Kaiserlich. Gesundheitsamte*, XX, 440-452, 7 figs.

PURDY, J. S. (1910). Flies and fleas as factors in disease. *Journ. Royal Sanitary Institute, Transactions*, XXX, 496-503.

QUILL, R. H. (1900). Report on an outbreak of enteric fever at Diyatalawa Camp, Ceylon. *Army Med. Rept.*, p. 452, Appendix 4.

RAIMBERT, A. (1869). Recherches expérimentales sur la transmission du charbon par les mouches. *Compt. rend. de l'Acad. de Sc.*, LXIX, 805-812.

SANDILANDS, J. E. (1906). Epidemic diarrhœa and the bacterial content of food. *Journ. of Hygiene*, VI, 77-92.

SANGREE (1899). *N. Y. Med. Record*, LV, 88.

SAVAGE, W. G. (1907). Recent work on typhoid fever bacteriology. *Public Health*, Oct.

SAWTCHENKO, J. D. (1892). De rôle des mouches dans la propagation de l'épidémie cholerique. Review in *Ann. de l'Institut Pasteur*, VII.

SEDGWICK, W. T., and WINSLOW, C. E. A. (1902). Statistical studies on the seasonal prevalence of typhoid fever in various countries and its relation to seasonal temperature. *Mem. Am. Acad. Sci.*, XII, Nov., 521-577, 8 charts.

SERIZIAT (1875). Études sur l'oasis de Biskra. Paris. (Cited by different authors.)

SIMMONDS, M. (1892). Fliegen und cholera-übertragung. *Deutsche Med. Wochenschr.*, 931.

SIMPSON, R. J. S. (1910). Medical history of the South African war. *Journ. Roy. Army Med. Corps,* XV, 3, 257 and 260-1.

SKINNER, H. (1909). The relation of house flies to the spread of disease. *New Orleans Med. and Surg. Journ.*, LXI, 12, 950-959. (Good bibliography added.)

SMITH, F. (1903, *et seq.*). Municipal sewerage. *Journ. Trop. Med.*, VI, 285-291, 304-308, 330-334, 353-355, 381-383.

SMITH, F. (1907). House flies and their ways at Benares. *Journ. Roy. Army Med. Corps,* IX, 150-155.

SMITH, T. (1908). The house fly as an agent in the dissemination of infectious diseases. *Am. Journ. of Public Hygiene,* XVIII, 3, 312-317.

SPILLMAN and HAUSHALTER (1887). Dissemination du bacilli de la tuberculose par la mouche. *Compt. Rend.*, CV, 352-353.

STILES, C. W. (1910). The sanitary privy: its purpose and construction. *Public Health Bulletin No. 37, U. S. Pub. Health and Marine-Hospital Service,* pp. 24, figs. 12.

SYKES, G. F. (1910). The distribution of flies in Providence, R. I. *Ann. Rept. Supt. Health, Providence,* for 1909, 7-15.

TASCHENBERG, E. L. (1879). Praktische Insekten-Kunde. Bremen. 5 vols. (House fly IV, 102-107.)

THAXTER, R. (1888). The Entomophthoreæ of the U. S. *Mem. Bost. Soc. Nat. Hist.*, IV, I, 133-201, 21 plates.

TIZZONI, G., and CATTANI, J. (1886). Untersuchungen über cholera. *Centralbl. f. d. Med. Wissensch.* Berlin. 769-771.

TOOTH, H. H., and CAVERLY, J. E. G. (1901). In *A Civilian War Hospital,* London, John Murray.

TSUZUKI, J. (1904). Bericht über meine epidemiologischen Beobachtungen Forschungen Während der Choleraepidemie in Nordchina in Jahre 1902. *Arch. f. Schiffs-u. Tropen-Hyg.*, VIII, 71-81.

UFFELMANN, J. (1892). Beiträge zur Biologie des cholerabacillus. *Berlin Klin. Wochenschr.*, 1213-1214.

VEEDER, M. A. (1898). The spread of typhoid and dysenteric diseases by flies. *Public Health*, XXIV, 260-262.

VEEDER, M. A. (1898). Flies as spreaders of disease in camps. *N. Y. Med. Rec.*, 429-430.

WELANDER (1896). Gonorrhœal ophthalmia carried by flies. *Wien. Klin. Wochenschr.*, No. 52.

WERNER, H. (1908). Über eine eingeisselige Flaggellaten form im Darm der Stubenfliege. *Arch. f. Protistenk.*, XIII, 19-22, 2 pls.

WHIPPLE, G. C. (1908). Typhoid fever, its causation, transmission and prevention, pp. 397, Wiley and Sons, N. Y., Chapman and Hall, London.

WILSON, E. (1868). Diseases of the skin (Philadelphia), p. 466.

WOODHOUSE, T. P. (1910). Notes on the causation and prevention of enteric fever in India. *Journ. Roy. Army Med. Corps*, X, 616.

YERSIN (1894). La Peste bubonique à Honkong. *Ann. Inst. Pasteur*, 662-667.

APPENDIX I

Flies Frequenting Human Dejecta and Those Found in Kitchens

In summing up the results of the work carried on by the writer, the number of species of insects found breeding in or frequenting human excrement was very large. There were many coprophagous beetles—forty-four species in all—and many Hymenopterous parasites, all of the latter having probably lived in the larval condition in the larvæ of Diptera or Coleoptera breeding in excrement. Neither the beetles nor the Hymenoptera, however, have any importance from the disease-transfer standpoint. The Diptera alone were the insects of significance in this connection. Of Diptera there were studied in all seventy-seven species, of which thirty-six were found to breed in human feces, while the remaining forty-one were captured upon such excrement. The following list indicates the exact species arranged under their proper families. The parenthetical remarks after each species should be estimated in the following order, from "scarce" to "extremely abundant": scarce, rather scarce, not abundant, moderately abundant, abundant, very abundant, extremely abundant.

REARED (USUALLY ALSO CAPTURED)

Family Chironomidæ

1. Ceratopogon sp. (scarce).

Family Bibionidæ

2. Scatopse pulicaria Loew (moderately abundant).

Family Empididæ

3. Tachydromia sp. (rather scarce).

Family Dolichopodidæ

4. Diaphorus leucostomus Loew (scarce).
5. Diaphorus sodalis Loew (not abundant).

Family Sarcophagidæ

6. Lucilia cæsar L. (abundantly captured; one reared).
7. Sarcophaga sarraceniæ Riley (abundant).
8. Sarcophaga assidua Walker (abundant).
9. Sarcophaga trivialis V. d. W. (abundant).
10. Helicobia quadrisetosa Coq. (very abundant).

Family Muscidæ

11. Musca domestica L. (abundant).
12. Morellia micans Macq. (abundant).
13. Muscina stabulans Fall. (abundant).
14. Myospila meditabunda Fabr. (abundant).

Family Anthomyidæ

15. Homalomyia brevis Rondani (very abundant).
16. Homalomyia canicularis L. (moderately abundant).
17. Homalomyia scalaris Fabr. (scarce).
18. Hydrotæa dentipes Meig. (moderately abundant).
19. Limnophora arcuata Stein (moderately abundant).
20. Ophyra leucostoma Wied. (abundant).
21. Phorbia cinerella Fall. (abundant).
22. Phorbia fusciceps Zett. (moderately abundant).

Family Ortalidæ

23. Euxesta notata Wied. (moderately abundant).

Family Lonchæidæ

24. Lonchæa polita Say (moderately abundant).

Family Sepsidæ

25. Sepsis violacea Meig. (extremely abundant).
26. Nemopoda minuta Wied. (very abundant).

Family Drosophilidæ

27. Drosophila ampelophila Loew (moderately abundant).

Family Oscinidæ

28. Oscinis trigramma Loew (rather scarce).

Family Agromyzidæ

29. Ceratomyza dorsalis Loew (rather scarce).
30. Desmometopa latipes Meig. (rather scarce).

Family Ephydridæ

31. Scatella stagnalis Fall. (scarce).

Family Borboridæ

32. Limosina albipennis Rond. (very abundant).
33. Limosina fontinalis Fall. (very abundant).
34. Sphærocera pusilla Meig. (abundant).
35. Sphærocera subsultans Fabr. (very abundant).

Family Scatophagidæ

36. Scatophaga furcata Say (very abundant).

CAPTURED (NOT REARED)

Family Chironomidæ

1. Chironomus halteralis Coq. (scarce).

Family Tipulidæ

2. Limnobia sciophila O. S. (scarce).

Family Empididæ

3. Rhamphomyia manca Coq. (not abundant).

Family Dolichopodidæ

4. Neurigonia tenuis Loew (scarce).

Family Sarcophagidæ

5. Chrysomyia macellaria Fabr. (rather abundant).
6. Calliphora erythrocephla Meig. (rather abundant).
7. Sarcophaga lambens Wied. (rather scarce).
8. Sarcophaga plinthopyga Wied. (rather scarce).
9. Cynomyia cadaverina Desv. (rather scarce).
10. Phormia terrænovæ Desv. (very abundant).

Family Muscidæ

11. Muscina cæsia Meig. (scarce).
12. Muscina tripunctata V. d. W. (scarce).
13. Stomoxys calcitrans L. (rather abundant).
14. Pseudopyrellia cornicina Fabr. (abundant).
15. Pyrellia ochricornis Wied. (rather scarce).

Family Anthomyiidæ

16. Hylemyia juvenalis Stein (rather scarce).
17. Hydrotæa metatarsata Stein (rather scarce).
18. Cœnosia pallipes Stein (rather scarce).
19. Mydæa palposa Walker (rather scarce).

Family Ortalidæ

20. Rivellia pallida Loew (rather scarce).

Family Sepsidæ

21. Piophila casei L. (rather scarce).

Family Drosophilidæ

22. Drosophila funebris Meig. (scarce).
23. Drosophila busckii Coq. (scarce).

FAMILY OSCINIDÆ

24. Hippelates flavipes Loew (rather scarce).
25. Oscinis carbonaria Loew (moderately abundant).
26. Oscinis coxendix Fitch (scarce).
27. Oscinis pallipes Loew (rather scarce).
28. Elachiptera costata Loew (moderately abundant).

FAMILY EPHYDRIDÆ

29. Discocerina parva Loew (rather scarce).
30. Hydrellia formosa Loew (rather scarce).

FAMILY BORBORIDÆ

31. Borborus equinus Fall. (very abundant, undoubtedly breeds here also).
32. Borborus geniculatus Macq. (moderately abundant).
33. Limosina crassimana Hal. (abundant).

FAMILY SYRPHIDÆ

34. Syritta pipiens L. (scarce).

FAMILY PHORIDÆ

35. Phora femorata Meig. (scarce).

FAMILY SCATOPHAGIDÆ

36. Scatophaga stercoraria L. (moderately abundant).
37. Fucellia fucorum Fall. (rather scarce).

FAMILY MICROPEZIDÆ

38. Calobata fasciata Fabr. (rather scarce).
39. Calobata antennipes Say (moderately abundant).

FAMILY HELOMYZIDÆ

40. Leria pectinata Loew (scarce).
41. Tephrochlamys rufiventris Meig. (scarce).

It should be stated here that this list, containing as it does only a record of actual observations, should by no means be considered as indicating definitely the habits of the species or their relative abundance under

other conditions. Thus some of the species here indicated as scarce in connection with excrement may be very common under other conditions, which would indicate that their occurrence upon excrement was more or less accidental. Moreover, certain of the species which have been captured on excrement, but not reared from it, are nevertheless undoubtedly excrement breeders, as will be proved by future observations. Thus we have in several cases certain species which have been reared while congeneric species have simply been captured, as, for example, Nos. 7 and 8 of the captured species are congeneric with 7, 8 and 9 of the reared series; 11 and 12 of the captured series are congeneric with 13 of the reared series; 17 of the captured series is congeneric with 18 of the reared series; 22 and 23 of the captured series are congeneric with 27 of the reared series; 25, 26 and 27 of the captured series are congeneric with 28 of the reared series; 33 of the captured series is congeneric with 32 and 33 of the reared series, and is undoubtedly an excrement breeder, and the same may be said of 36 of the captured series which is congeneric with 36 of the reared.

From these data it will be noticed that the most abundant species reared were *Helicobia quadrisetosa, Sepsis violacea, Nemopoda minuta, Limosina albipennis, Limosina fontinalis, Sphærocera subsultans,* and *Scatophaga furcata,* while the most abundant forms captured on excrement were *Phorbia terrænovæ* and *Borborus equinus.* It will also be noticed that among the reared forms there are ten others which are simply

entered as "abundant," and among the captured two others. With these facts in mind we are prepared to examine the results of the kitchen and dining-room captures.

The results so far stated have a distinct entomological interest as regards the exact food habits of a large number of species, many of the observations being novel contributions to previous knowledge of these forms; but the practical bearing of the work is only brought out when we consider which of these forms are likely from their habits actually to convey disease germs from the excrement in which they have bred, or which they have frequented, to substances upon which people feed. Therefore collections of the Dipterous insects occurring in kitchens and pantries were made, with the assistance of correspondents and observers in different parts of the country, all through the summer of 1899 and also in the summer and autumn of 1900. Such collections were made in the States of Massachusetts, New York, Pennsylvania, District of Columbia, Virginia, Florida, Georgia, Louisiana, Nebraska, and California. Nearly all of the flies thus captured were caught upon sheets of the ordinary sticky fly paper, which, while ruining them as cabinet specimens, did not disfigure them beyond the point of specific recognition. The others were captured in the ordinary manner.

In all there were examined 23,087 flies, which had been caught in rooms in which food supplies were ordinarily exposed; and they may safely be said to have

been attracted by the presence of these food supplies. Of these 23,087 flies, 22,808 were *Musca domestica, i. e.,* ninety-eight and eight-tenths per cent. of the whole number captured. The remainder, consisting of one and two-tenths per cent. of the whole, comprised various species, the most significant ones being *Homalomyia canicularis* (the species ordinarily called the "little house fly") of which eighty-one specimens were captured; the stable fly (*Muscina stabulans*), thirty-seven specimens; *Phora femorata,* thirty-three; *Lucilia cæsar,* eighteen; *Drosophila ampelophila,* fifteen; *Sarcophaga trivialis,* ten; *Calliphora erythrocephala,* seven. *Musca domestica* is, therefore, the species of great significance. *Homalomyia canicularis* is important. *Muscina stabulans* is of somewhat lesser importance. *Drosophila ampelophila* is an important form, and had more of the captures been made in the autumn its numbers would probably have been greater, since beyond doubt it is an abundant species in houses after fruit has begun to make its appearance (say, in August and September and on until winter time) in pantries and on dining-room sideboards. The Calliphora and the Lucilia are of slight importance, not only on account of their rarity in houses, but because they are not true excrement insects. Other forms were taken, but either their household occurrence was probably accidental, or from their habits they have no significance in the disease-transfer function.

—Extracted from: A Contribution to the Study of the Insect Fauna of Human Excrement. By L. O. Howard (p. 547).

APPENDIX II

On Some Flies Reared from Cow Manure*

IN the summer of 1889, while engaged in an investigation of the habits and life history of the horn fly of cattle (*Hæmatobia serrata*), the writer at various times brought to Washington, from different points in Virginia, large quantities of cow manure collected in the field, and eventually succeeded in working out the complete life history of the horn fly, as displayed in Insect Life, Vol. II, No. 4, October, 1889. In this article the statement is made, in concluding, that the observations were greatly hindered and rendered difficult by the fact that fresh cow dung is the nidus for a number of species of Diptera, some about the same size and general appearance as the horn fly, and that no less than twenty distinct species of flies had been reared from horse and cow dung, mainly the latter, and six species of parasitic insects as well. The plan finally adopted of securing the isolation of the horn flies was to remove the eggs from the surface of the dung and place them with dung which was absolutely fresh and collected practically as it fell from the cow. A report upon the other species was promised, but was never published, although Professor Riley, in his re-

*Reprinted from an article with this title, by L. O. Howard, published in the *Canadian Entomologist,* Vol. 33 (1901), pp. 42-44.

port for 1890, listed eight parasites, only two of which were specifically determined.

The writer's recent investigations of the insect fauna of human excrement (Proc. Wash. Acad. of Sciences, Vol. II, pp. 541-604. Dec. 28, 1900) aroused his interest in the general subject of coprophagous insects, and the flies reared in 1889-90, from cow dung, were looked up and have been named by Mr. D. W. Coquillett. The list is so interesting that it should be recorded. It will be noticed that several of the species are identical with those found breeding in human excrement. These are: *Sarcophaga incerta, Helicobia quadrisetosa, Musca domestica, Morellia micans, Myospila meditabunda, Ophyra leucostoma, Sepsis violacea, Sphærocera subsultans* and *Limosina albipennis.* The rearing of *Ceratopogon specularis* from cow dung is of especial interest, since, down to the record in the Washington Academy paper just referred to, no insects of this genus had been found to be coprophagous. Some of the other records are interesting for the same reason. The list follows:

Family Cecidomyidæ

Diplosis, sp. Issued Dec. 26, 1889; and Jan. 18, 1890; 4 specimens.

Family Mycetophilidæ

Sciara, sp. Issued March 26 and 29, 1890; 2 specimens.

Family Chironomidæ

Camptocladius byssinus, Schrank. Issued Jan. 2, 1890. Issued Dec. 31, 1889; and March 25, 1890; 9 specimens.

Camptocladius minimus, Meigen. Issued Dec. 23, 26, 27, 30 and 31, 1889; Jan. 13, 18, and March 25, 1890; 12 specimens.

Ceratopogon specularis, Coq. Issued August 28, 1889. Issued Dec. 30, 1889; 6 specimens.

Psychoda minuta, Banks. Issued Dec. 26, 30 and 31, 1889; and Jan. 11, 1890; 4 specimens.

FAMILY RHYPHIDÆ

Rhyphus punctatus, Fabr. Issued Sept. 2, 3, and 4, 1889. Issued Jan. 13, 16, 18, 20, 22, 24 and 29, Feb. 1, March 26 and 29, and April 5 and 9, 1890; 64 specimens.

FAMILY SARCOPHAGIDÆ

Sarcophaga incerta, Walker. Issued Aug. 31, 1889. Issued Aug. 30, 1889; 7 specimens.

Sarcophaga, sp. Issued April 23, 1890; 1 specimen.

Helicobia quadrisetosa, Coq. Issued Aug. 6 and 30, 1889; 2 specimens.

Pollenia rudis, Fabr. Issued Dec. 23, 1889; 1 specimen.

FAMILY MUSCIDÆ

Musca domestica, Linné. Issued Aug. 30 and Sept. 2 and 4, 1889; 20 specimens.

Morellia micans, Macq. Issued Aug. 30, 1899. Issued Dec. 23, 26, 27, 28, 30 and 31, 1889; Jan. 2, 6, 8, 9, 10, 11, 13, 14, 16, 17, 18, 20, 25 and 27, Feb. 1, March 25, April 5 and 9, 1890; 125 specimens.

Myospila meditabunda, Fabr. Issued Aug. 26, 28, 29, 30, Dec. 23, 1889; Jan. 9, March 25, 26, April 2, 9, 14, 15, 1890. Issued April 5, 1890; 48 specimens.

Hæmatobia serrata, Desv. Sept. 17, 2 specimens.

FAMILY ANTHOMYIDÆ

Hydrotæa armipes, Fallen. Issued Sept. 27, 30, Oct. 4, 1889; Jan. 2, 6, 7, 8, 9, 10, April 24, 1890; 38 specimens.

Ophyra leucostoma, Wied. Issued Sept. 6, 1889; 11 specimens.

Limnophora, sp. Issued Aug. 30, 31, 1889; 5 specimens.

Cœnosia lata, Walker. Issued April 25, 1890; 1 specimen.

Cœnosia flavicoxæ, Stein. Issued Aug. 31, 1889; 4 specimens.

Phorbia, sp. Issued March 29, 1890; 1 specimen.

FAMILY SEPSIDÆ

Sepsis violacea, Meigen. Issued Aug. 28, 1889; 8 specimens.

FAMILY BORBORIDÆ

Sphærocera subsultans, Fabr. Issued Aug. 30, 1889; 7 specimens.

Limosina albipennis, Rondani. Issued August 28, Dec. 23, 1889; 2 specimens.

APPENDIX III

Regulations of the Health Department of the District of Columbia Relating to House Flies

EXTRACT from An Ordinance to Revise, Consolidate, and Amend the Ordinances of the Board of Health, etc., as Amended by Commissioners' Orders.

Sec. 3. That manure, accumulated in great quantities; manure, offal, or garbage piled or deposited within 300 feet of any place of worship, or of any dwelling, or unloaded along the line of any railroad, or in any street or public way; cars or flats loaded with manure, or other offensive matter, remaining or standing on any railroad, street or highway in the cities of Washington or Georgetown, or in the more densely populated suburbs of said cities, are hereby declared nuisances injurious to health; and any person who shall pile or deposit manure, offal, or garbage, or any offensive or nauseous substance within 300 feet of any inhabited dwelling within the limits of said cities or their said suburbs, and any person who shall unload, discharge, or put upon or along the line of any railroad, street, or highway, or public place within said cities or their said suburbs any manure, garbage, offal, or other offensive or nauseous substance within 300 feet of any inhabited dwelling, or who shall cause or allow cars or flats loaded with or having in or upon them

any such substance to remain or stand in or along any railroad, street, or highway within the limits of said cities or their suburbs within 300 feet of any inhabited dwelling, and who shall fail, after notice duly served by this board, to remove the same, shall, upon conviction thereof, be fined not less than five nor more than twenty-five dollars for every such offense.

* * * * * * *

SEC. 18 *A*. No person owning, occupying or having use of any stable, shed, pen, stall, or other place within any of the more densely populated parts of the District of Columbia, where animals of any kind are kept shall permit such stable, shed, pen, stall, or place to become or to remain filthy or unwholesome.

SEC. 18 *B*. No person shall use any stable, nor shall any person having the power and authority to prevent permit any person to use any stable, within any of the more densely populated parts of the District of Columbia, after the first day of July, 1907, unless the surface of the ground beneath every stall and for a distance of four feet from the rear thereof be covered with a water-tight floor laid with such grades as will cause all fluids that fall upon it to flow as promptly as possible, if a public sewer be available, into the public sewer, and, if a public sewer be not available, to that portion of the premises where they will cause the least possible nuisance.

SEC. 18 *C*. Every person owning or occupying any building or part of a building within any of the more densely populated parts of the District of Columbia,

where one or more horses, mules, cows, or similar animals are kept, shall maintain in connection therewith a bin or pit for the reception of manure, and, pending the removal from the premises of the manure from the animal or animals aforesaid, shall place such manure in said bin or pit. The bin or pit required by this regulation shall be located at a point as remote as practicable from any dwelling, church, school or similar structure, owned or occupied by any person or persons in the neighborhood of said bin or pit, other than the owner or occupant of the building or part of building aforesaid, and as remote as practicable from any public street or avenue; shall be so constructed as to exclude rain water, and shall in all other respects be water-tight except as it may be connected with the public sewer or as other definite provision may be made for cleaning and flushing from time to time; shall be provided with a suitable cover, and constructed so as to prevent in so far as may be practicable the ingress and egress of flies. No bin or pit shall be constructed the bottom of which is below the level of the surface of the surrounding earth unless it be of substantial masonry and connected with the public sewer. The provisions of this paragraph shall take effect from and after the expiration of three months immediately following its promulgation.

SEC. 18 *D*. No person owning or occupying any building or part of a building located within any of the more densely populated parts of the District of Columbia, in which building or part of a building any horse,

mule, cow, or similar animal is kept, shall keep any manure, or permit any manure to be kept, in or upon any portion of the premises other than the bin or pit provided for that purpose; nor shall any person aforesaid allow any such bin or pit to be overfilled or to be needlessly uncovered.

SEC. 18 *E*. The provisions of paragraphs *C* and *D* shall not apply to the keeping of manure from horses when such manure is kept tightly rammed into well-covered barrels for the purpose of removal in such barrels.

SEC. 18 *F*. No person shall permit any manure to accumulate on premises under his control in such a manner or to such an extent as to give rise to objectionable odors upon any public highway or upon any premises owned or occupied by any person other than the person owning or occupying the premises on which said manure is located. Every person having the use of any manure bin or pit and every person keeping manure, in any of the more densely populated parts of the District of Columbia, shall cause all such manure to be removed from the premises at least twice every week between June first and October thirty-first, inclusive, of each year, and at least once every week between November first of each year and May thirty-first of the following year, both dates inclusive.

SEC. 18 *G*. Every person using within the District of Columbia any building, or any portion of a building, in the city of Washington, or in any of the more

densely populated suburbs thereof, as a stable for one or more horses, mules, or cows, shall report that fact to the health officer in writing, within thirty days after this regulation takes effect, giving his or her name, and the location of such stable, and the number and the kind of the animals stabled therein; and thereafter every person occupying any building, or any portion of a building, in the city of Washington, or in any of the more densely populated suburbs thereof, for the purpose aforesaid, shall report in like manner his or her name and the location of said stable, and the number and kind of animals stabled therein, within five days after the beginning of his or her occupancy of such buildings; provided, that stables recorded at the Health Office as parts of dairy farms in the District of Columbia need not be so reported.

SEC. 18 *H*. No person who has removed manure from any bin or pit, or any other place where manure has been accumulated, shall deposit such manure in any place within any of the more densely populated parts of the District of Columbia without a permit from the health officer authorizing him so to do and then only in accordance with the terms of such permit. The provisions of this paragraph shall not apply to the distribution of manure over lawns and parking when such manure has been so thoroughly rotted or decomposed that its distribution gives rise to no offensive odors on adjacent properties or on public thoroughfares.

SEC. 18 *I*. Any person violating any of the provisions of this section shall upon conviction thereof be

punished by a fine of not more than forty dollars for each offense.

Extract from Article IX, Police Regulations.

ARTICLE IX

SEC. 10. No person shall remove or transport any manure over any public highway in any of the more densely populated parts of the District of Columbia except in a tight vehicle, which if not enclosed must be effectually covered with canvas so secured to the sides and ends of the vehicle as to prevent the manure from being dropped while being removed, and so as to limit as much as practicable the escape of odors from said manure.

SEC. 20. Manure may be deposited in pits below the surface of alleys that are not less than fifteen feet wide, but the pit must not extend more than four feet beyond the building line. The walls must be substantial and water-tight, with stone or iron coping, bedded in cement, set fair with the surface of the alley. They must be covered with heavy wrought-iron doors, flush with the alley pavement or surface, sufficiently strong to carry heavily loaded carts or other vehicles, and provided with ventilation by means of a flue inside of the stable and extending above the roof of the same, and they must be drained by sewer connections, as directed by the Inspector of Plumbing.

EXECUTIVE OFFICE
COMMISSIONERS OF THE DISTRICT OF COLUMBIA

ORDERED: WASHINGTON, April 11, 1908.

That, Pursuant to the authority vested in the Commissioners by the "Joint Resolution authorizing the Commissioners of the District of Columbia to alter, amend, or repeal certain health ordinances" approved February 28, 1899, "An ordinance to prevent the sale of unwholesome food in the cities of Washington and Georgetown" as amended by Commissioners' orders of January 2, 1902; April 21, 1903; October 6, 1904; April 24, 1906; May 31, 1907, and June 10, 1907, is hereby further amended by inserting after the word "effectually" in section 13 thereof the phrase "or effectually protected by a power-driven fan or fans," so that said section shall read as follows:

SEC. 13. Every manager of a store, market, dairy, café, lunch room, or any other place in the District of Columbia, where a food, or a beverage, or confectionery, or any similar article, is manufactured or prepared for sale, stored for sale, offered for sale, or sold, shall cause it to be screened effectually, or effectually protected by power-driven fan or fans, so as to prevent flies and other insects from obtaining access to such food, beverage, confectionery, or other article, and shall keep such food, beverage, confectionery, or other article free from flies and other insects at all times. Any person violating the provisions of this regulation shall, upon conviction thereof, be punished by a fine of not more than twenty-five dollars for each and every such offense. This regulation shall take effect from and after the expiration of thirty days immediately following the date of its promulgation.

Official copy furnished Health Department.

By order:

WM. TINDALL, Secretary.

Officially published in the Washington *Herald* April 16, 1908.

EXECUTIVE DEPARTMENT

COMMISSIONERS OF THE DISTRICT OF COLUMBIA

WASHINGTON, December 1, 1909.

ORDERED:

That Section 60 of "An Ordinance to prevent the sale of unwholesome food in the cities of Washington and Georgetown" as amended by orders of the Commissioners of the District of Columbia, be, and the same is hereby amended so as to read as follows:

SEC. 60. No person shall expose for sale on any public highway or in any uninclosed market, store, shop, stand, or stall, or in any open lot, or transport over any public highway to any place for sale there or elsewhere, in the District of Columbia, any meat, fish, plucked poultry or game bird, dressed rabbit or squirrel, butter, butterine, oleomargarine, lard, lard compound or substitute, cheese, candy, cake, bread, dates, figs, or any food whatsoever of a kind not commonly washed, peeled, shelled or cooked, before eaten, unless the same be then and there effectually and in a cleanly manner wrapped, or covered and enclosed, so as to protect it from dust and insects.

No person shall expose for sale in any place aforesaid between April 1st and October 31st, inclusive, of any year, any fresh meat or fresh fish unless said meat or fish, while thus exposed, be kept at a temperature not exceeding fifty-five degrees Fahrenheit.

Official copy furnished.

By order:

WM. TINDALL,
Secretary.

Officially published in the Washington *Post,* December 3, 1909.

APPENDIX IV

Directions for Building a Sanitary Privy*

IN order to put the construction of a sanitary privy for the home within the carpentering abilities of boys, a practical carpenter has been requested to construct models to conform to the general ideas expressed in this article, and to furnish estimates of the amount of lumber, hardware, and wire screening required. Drawings of these models have been made during the process of construction (Figs. 36, 37) and in completed condition (Figs. 38, 39). The carpenter was requested to hold constantly in mind two points, namely, (1) economy and (2) simplicity of construction. It is believed that any fourteen-year-old schoolboy of average intelligence and mechanical ingenuity can, by following these plans, build a sanitary privy for his home at an expense for building materials, exclusive of receptacle, of five to ten dollars, according to locality. It is further believed that the plans submitted cover the essential points to be considered. They can be elaborated to suit the individual taste of persons who prefer a more elegant and more expensive structure. For instance, the roof can have a double instead of a single slant, and can be shingled; the sides, front, and back can be clapboarded or they can be shingled. Instead

*Taken from Public Health Bull. No. 37, U. S. Public Health and Marine Hospital Service. By C. W. Stiles, Ph.D., Washington, 1910.

of one seat or six seats, there may be two, three, four, or five seats, etc., according to necessity.

A Single-Seated Privy for the Home

Nearly all privies for the home have seats for two persons, but a single privy can be made more economically.

Framework (Fig. 36).—The lumber required for the framework (Fig. 37) of the outhouse shown as completed in Fig. 38 is as follows:

A. Two pieces of lumber (scantling) 4 feet long and 6 inches square at ends.

B. One piece of lumber (scantling) 3 feet 10 inches long; 4 inches square at ends.

C. Two pieces of lumber (scantling) 3 feet 4 inches long; 4 inches square at ends.

D. Two pieces of lumber (scantling) 7 feet 9 inches long; 2 by 4 inches at ends.

E. Two pieces of lumber (scantling) 6 feet 7 inches long; 2 by 4 inches at ends.

F. Two pieces of lumber (scantling) 6 feet 3 inches long; 2 by 4 inches at ends.

G. Two pieces of lumber (scantling) 5 feet long; 2 by 4 inches at ends.

H. One piece of lumber (scantling) 3 feet 10 inches long; 2 by 4 inches at ends.

I. Two pieces of lumber (scantling) 3 feet 4 inches long; 2 by 4 inches at ends.

J. Two pieces of lumber (scantling) 3 inches long; 2 by 4 inches at ends.

K. Two pieces of lumber (scantling) 4 feet 7 inches long; 6 inches wide by 1 inch thick. The ends of *K* should be trimmed after being nailed in place.

L. Two pieces of lumber (scantling) 4 feet long; 6 inches wide, and 1 inch thick.

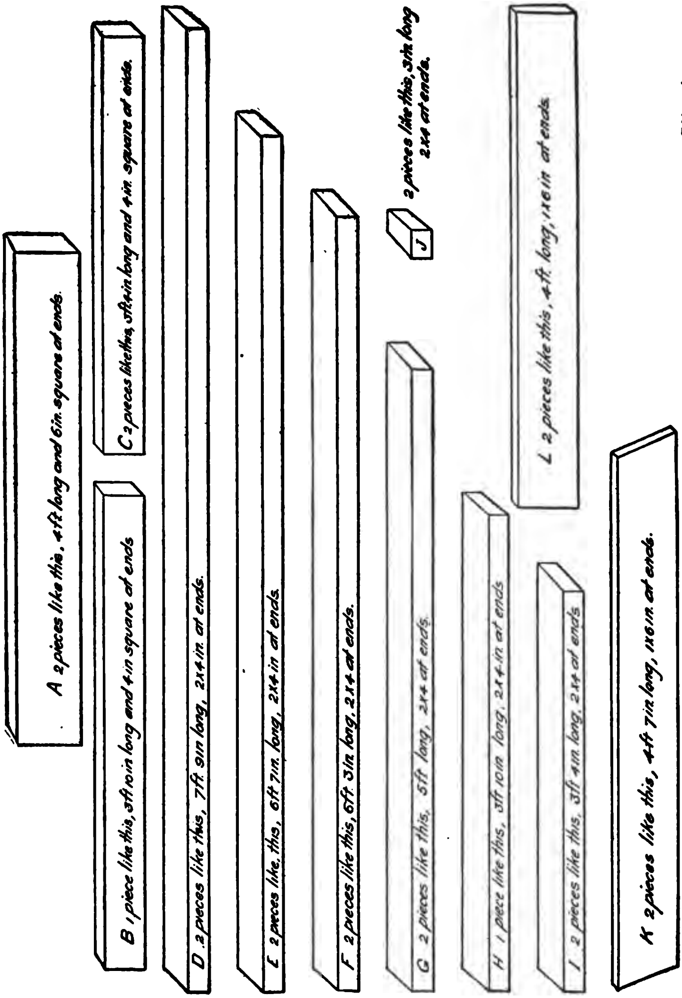

Fig. 36.—Scantling for framework of single-seated privy. (Redrawn from Siles.)

First lay down the sills marked A and join them with the joist marked B; then nail in position the two joists marked C, with their ends 3 inches from the [illegible] D and F), inner edge of A; raise the corner posts [illegible] and joining them spiking them at bottom to A and C and joining them with L, I, G, and E; raise door posts E, fastening them at [illegible] in position; H is fastened [illegible] (Fig. [illegible]).

Sides.—Each side requires four boards [illegible] 12 inches [illegible] long; these are wide by 1 inch thick and [illegible]. The corner boards [illegible] bottom or are [illegible] on the side boards [illegible] (Fig. [illegible]) [illegible] 12 inches [illegible]

Back.—The back requires two boards [illegible] long, and two wide by 1 inch thick and 6 feet 5 [illegible] boards 12 inches wide by 1 inch [illegible] are nailed inches long. The two [illegible] boards are each sawed in [illegible] the sides [illegible] measures 1 feet [illegible] inches. [illegible] longer portion [illegible] the shorter [illegible] the back door. [illegible] is nailed [illegible] which portion [illegible] boards

Floor.—The floor requires four boards [illegible] inches wide, [illegible] (Fig. [illegible]) and [illegible] be nailed on.

Front.—The front boards [illegible] two boards [illegible] The front requires [illegible] thick 9 [illegible]

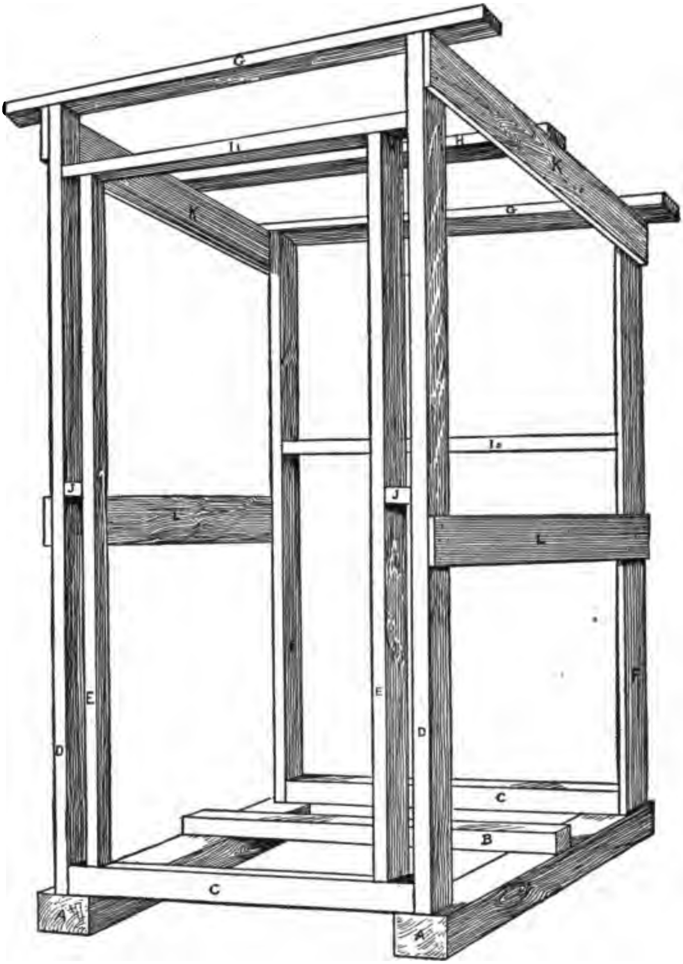

Fig. 37.—The framework for a single-seated privy. (Redrawn from Stiles.)

First lay down the sills marked *A* and join them with the joist marked *B;* then nail in position the two joists marked *C,* with their ends 3 inches from the outer edge of *A;* raise the corner posts (*D* and *F*), spiking them at bottom to *A* and *C,* and joining them with *L,* I_2, *G,* and *K;* raise door posts *E,* fastening them at *J,* and then spike I_1 in position; *H* is fastened to *K.* (Fig. 37.)

Sides.—Each side requires four boards (*a*) 12 inches wide by 1 inch thick and 8 feet 6 inches long; these are nailed to *K, L,* and *A.* (Fig. 37.) The corner boards are notched at *G,* allowing them to pass to bottom or roof; draw a slant from front to back at *G-G,* on the outside of the boards, and saw the four side boards to correspond with this slant. (Fig. 39.)

Back.—The back requires two boards (*b*) 12 inches wide by 1 inch thick and 6 feet 11 inches long, and two boards 12 inches wide by 1 inch thick and 6 feet 5 inches long. The two longest boards (*b*) are nailed next to the sides; the shorter boards are each sawed in two so that one piece (c^1) measures 4 feet 6 inches, the other (c^2) 1 foot 11 inches; the longer portion (c^1) is nailed in position above the seat; the shorter portion (c^2) is utilized in making the back door.

Floor.—The floor requires four boards (*d*) which (when cut to fit) measure 1 inch thick, 12 inches wide, and 3 feet 10 inches long. (Fig. 38.)

Front.—The front boards may next be nailed on. The front requires (aside from the door) two boards (*E*) which (when cut to fit) measure 1 inch thick, 9

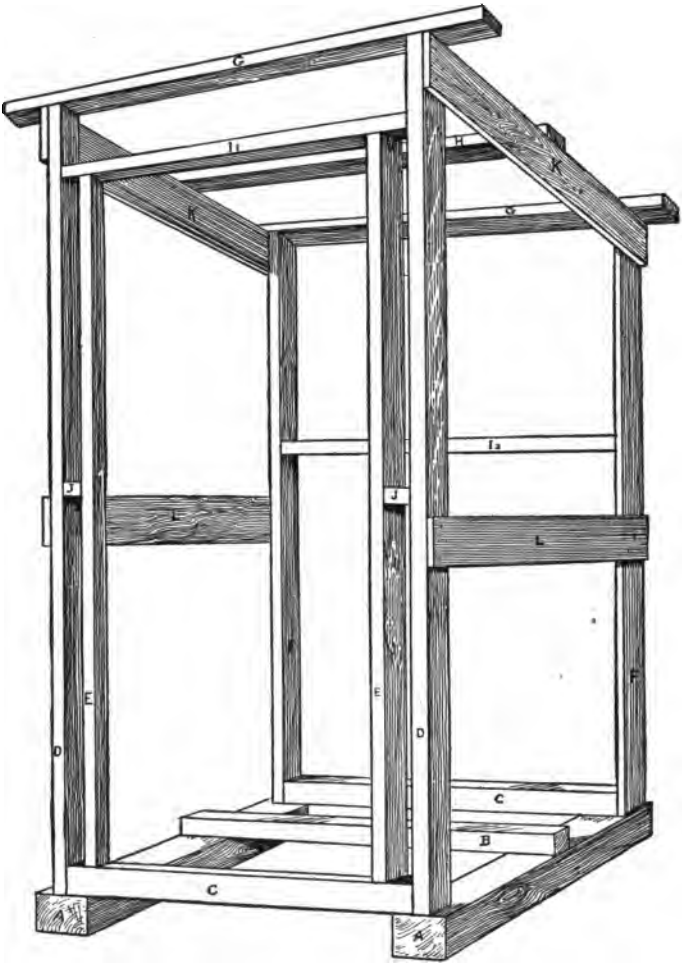

Fig. 37.—The framework for a single-seated privy. (Redrawn from Stiles.)

inches wide, and 8 feet 5 inches long; these are nailed next to the sides. (Fig. 38.)

Roof.—The roof may now be finished. This requires five boards (*f*), measuring (when cut to fit) 1 inch thick, 12 inches wide, and 6 feet long. They are so placed that they extend 8 inches beyond the front. The joints (cracks) are to be broken (covered) by laths one-half inch thick, 3 inches broad, and 6 feet long. (Fig. 39.)

Box.—The front of the box may be made with two boards, 1 inch thick, 3 feet 10 inches long. One may measure 12 inches wide, the other 5 inches wide. These are nailed in place, so that the back of the boards is 18 inches from the inside of the back-boards. The seat of the box may be made with two boards, 1 inch thick, 3 feet 10 inches long; one may measure 12 inches wide, the other 7 inches wide. One must be jogged (cut out) to fit around the back corner posts (*F*). An oblong hole, 10 inches long and 7½ inches wide, is cut in the seat. The edge should be smoothly rounded or beveled. An extra (removable) seat for children may be made by cutting a board 1 inch thick, 15 inches wide, and 20 inches long; in this seat a hole is cut, measuring 7 inches long by 6 inches wide; the front margin of this hole should be about 3 inches from the front edge of the board; to prevent warping, a cross cleat is nailed on top near or at each end of the board.

A cover (*K*) to the seat should measure 1 inch thick by 15 inches wide by 20 inches long; it is cleated on

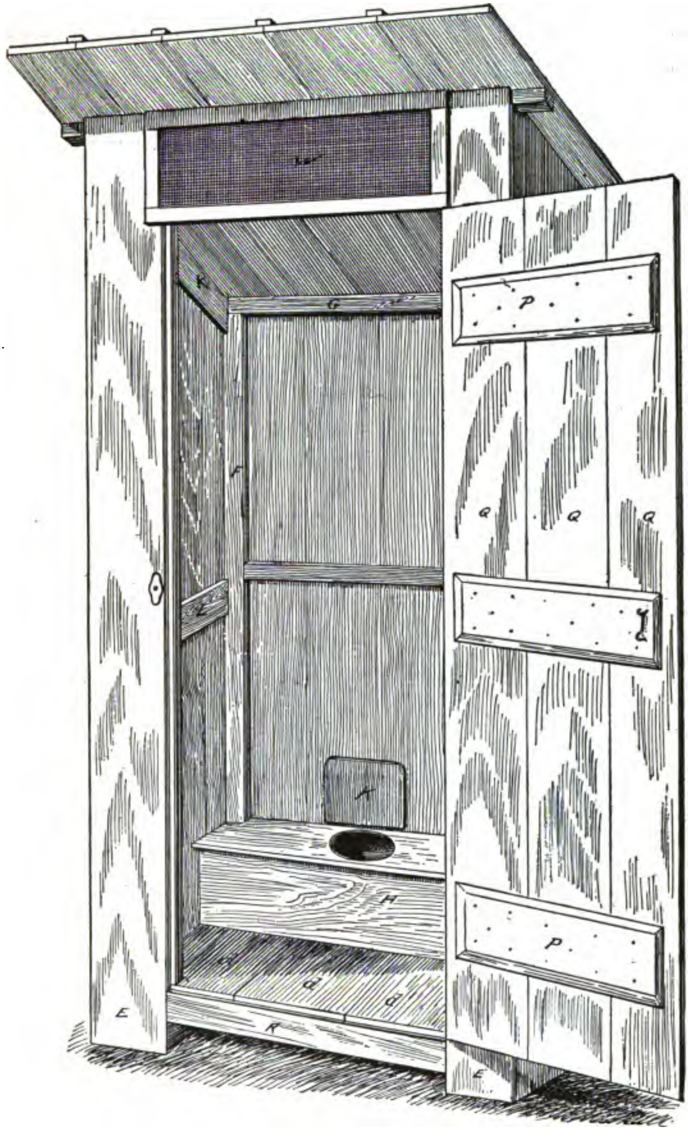

Fig. 38.—Front view of single-seated sanitary privy. (Redrawn from Stiles.)

top near the ends, to prevent warping; it is hinged in back to a strip 1 inch thick, 3 inches wide, and 20 inches long, which is fastened to the seat. Cleats may also be nailed on the seat at the sides of the cover. On the inside of the backboard, 12 inches above the seat, there should be nailed a block (1), 2 inches wide, 6 inches long, extending forward 3¼ inches; this is intended to prevent the cover from falling backward and to make it to fall down over the hole when the occupant rises.

On the floor of the box (underneath the seat) two or three cleats are nailed in such a position that they will always center the tub; the position of these cleats depends upon the size of the tub.

Back door.—In making the back of the privy the two center boards were sawed at the height of the bottom of the seat. The small portions (c^2) sawed off (23 inches long) are cleated (*O*) together so as to form a back door which is hinged above; a bolt or a button is sufficient arrangement to keep the door closed.

Front door.—The front door, Fig. 38, is made by cleating (*p*) together three boards (*Q*) 1 inch thick, 10 inches wide, and (when finished) 6 feet 7 inches long; it is best to use three cross-cleats (*p*) (1 inch thick, 6 inches wide, 30 inches long), placed on the inside. The door is hung with two hinges (6-inch "strap" hinges will do), which are placed on the right as one faces the privy, so that the door opens from the left. The door should close with a coil spring (cost

about 10 cents) or with a rope and weight, and may fasten on the inside with a catch or a cord. Under

Fig. 39.—Rear view of single-seated sanitary privy. (Redrawn from Stiles.)

the door a crosspiece (*R*) 1 inch thick, 4 inches wide, 30 inches long (when finished) may be nailed to the

joist. Stops may be placed inside the door. These should be 1 inch thick, 3 inches wide, and 6 feet 6 inches long, and should be jogged (that is to say, cut out) to fit the cross-cleats (*p*) on the door. Close over the top of the door place a strip 1 inch thick, 2 inches wide, 30 inches long, nailed to I. (Fig. 37). A corresponding piece is placed higher up directly under the roof, nailed to G. A strap or door-pull is fastened to the outside of the door.

Ventilators.—There should be five ventilators (*w*). One is placed at each side of the box directly under the seat; it measures 6 to 8 inches square. Another (12 inches square) is placed near the top on each side of the privy. A fifth (30 inches long 8½ inches wide) is placed over the door, between G and I (Figs. 37, 38). The ventilators are made of 15-mesh copper wire, which is first tacked in place and then protected at the edge with the same kind of lath that is used on the cracks and joints.

Lath.—Outside cracks (joints) are covered with lath one-half inch thick by 3 inches wide.

Receptacle.—For a receptacle, saw a water-tight barrel to fit snugly under the seat; or purchase a can or tub, as deep (17 inches) as the distance from the under surface of the seat to the floor. If it is not possible to obtain a tub, barrel, or can of the desired size, the receptacle used should be elevated from the floor by blocks or boards so that it fits snugly under the seat. A galvanized can measuring 16 inches deep and 16 inches in diameter can be purchased for about $1, or

even less. An empty candy bucket can be purchased for about 10 cents.

Order for material.—The carpenter has made out the following order for lumber (pine, No. 1 grade) and hardware to be used in building a privy such as has been described:

1 piece scantling, 6 by 6 inches by 8 feet long, 24 square feet.
1 piece scantling, 4 by 4 inches by 12 feet long, 16 square feet.
5 pieces scantling, 2 by 4 inches by 16 feet long, 54 square feet.
3 pieces board, 1 by 6 inches by 16 feet long, 24 square feet.
2 pieces board, 1 by 9 inches by 9 feet long, 14 square feet.
3 pieces board, 1 by 10 inches by 7 feet long, 18 square feet.
15 pieces board, 1 by 12 inches by 12 feet long, 180 square feet.
12 pieces board, ½ by 3 inches by 16 feet long, 48 square feet.
2 pounds of 20-penny spikes.
6 pounds of 10-penny nails.
2 pounds of 6-penny nails.
7 feet screen, 15-mesh, copper, 12 inches wide.
4 hinges, 6-inch "strap," for front and back doors.
2 hinges, 6-inch "T," or 3-inch "butts," for cover.
1 coil spring for front door.

According to the carpenter's estimate, these materials will cost from $5 to $10, according to locality.

There is some variation in the size of lumber, as the pieces are not absolutely uniform. The sizes given in

the lumber order represent the standard sizes which should be ordered, but the purchaser need not expect to find that the pieces delivered correspond with mathematical exactness to the sizes called for. On this account the pieces must be measured and cut to measure as they are put together.

Estimate of Material for School Privy

The following estimate of building materials has been made by a carpenter for the construction of a six-seated school privy. The estimated cost of these materials is $25 to $50, according to locality; this does not include the pails, which ought not to cost over $1 apiece.

3 pieces scantling, 6 by 6 inches by 20 feet, 180 square feet.
1 piece scantling, 6 by 6 inches by 8 feet, 24 square inches.
Scantling, 2 by 4 inches, 165 square feet.
Boards, 1 by 12 inches, 600 square feet.
Boards, 1 by 10 inches, 185 square feet.
Boards, 1 by 8 inches, 100 square feet.
Boards, 1 by 6 inches, 80 square feet.
Boards, ½ by 3 inches, 100 square feet.
Flooring, 80 square feet.
40 feet 15-mesh copper wire screen, 12 inches wide.
12 pairs of hinges, 6-inch "strap."
6 pairs of hinges, 6-inch "T."
3 pounds of 20-penny spikes.
15 pounds of 10-penny nails.
8 pounds of 6-penny nails.
6 coil springs for front doors.
6 knobs or latches.

APPENDIX V

A Simple Apparatus for Use in the Safe Disposal of Night-Soil*

THE proper disposal of human excreta is recognized by sanitarians as the most important single measure needed to prevent the spread of typhoid fever, hookworm disease, the dysenteries, and certain other widely prevalent diseases.

Where large numbers of people are gathered together, as in cities, the removal of dejecta from persons becomes, from an esthetic standpoint at least, a necessity, and practically all modern cities have expended large sums of money to install sewerage systems, which, though usually removing the sewage in such a way as to prevent it from becoming an intolerable nuisance to sight and smell, yet frequently fall short of safety from a sanitary standpoint.

Though a city may dispose of its own sewage properly, its people are exposed to excreta-borne infections brought in on various food supplies from farms. Thus the sanitation of the farm is vastly important, not only to the rural population, but also to the urban, and therefore the farm as the fountain head of various and far-flowing streams of infection is the logical point to

*From Public Health Report No. 54. Preliminary Note on a Simple and Inexpensive Apparatus in Use in Safe Disposal of Night-Soil. By L. L. Lumsden, Norman Roberts, and Ch. Wardell Stiles.

attack in campaigns of prevention against many of the communicable diseases.*

Among the obstacles in progress in farm sanitation one of the chief has been the difficulty of convincing the farmer that the benefits which would accrue from proper disposal of excreta would justify the expense of constructing, and the disagreeable labor of maintaining, the sanitary devices proposed. Therefore, whatever can be done in simplification and in lessening expense and labor in the installation and maintenance of an efficient disposal system will increase the chances of its adoption.

The apparatus described in this note has been in use in one of the work rooms of the Hygienic Laboratory since July 12, 1910. It has been seen by a number of sanitarians from different sections of the country, and several of them have expressed a desire to test it for themselves. The details of construction are presented at this time in order to place them at the disposal of any persons who may desire to test the apparatus in question.

Starting point of studies.—Starting out on the principle that the forces of nature in fermentation should, if possible, be utilized, we have sought to meet the objections that have thus far occurred to us in respect to the wet system. Further, the importance of economy and of simplicity of construction has been constantly held in mind. An effort has also been made to reduce

*Freeman, Allen W., The Farm the Next Point of Attack in Sanitary Progress. Jour. A. M. A., August 27, 1910.

to a minimum the labor and skill involved in taking care of the privy, and, finally, while sanitary safety has been the chief object in mind, we have not ignored the widespread demand that human excreta be turned to economic account.

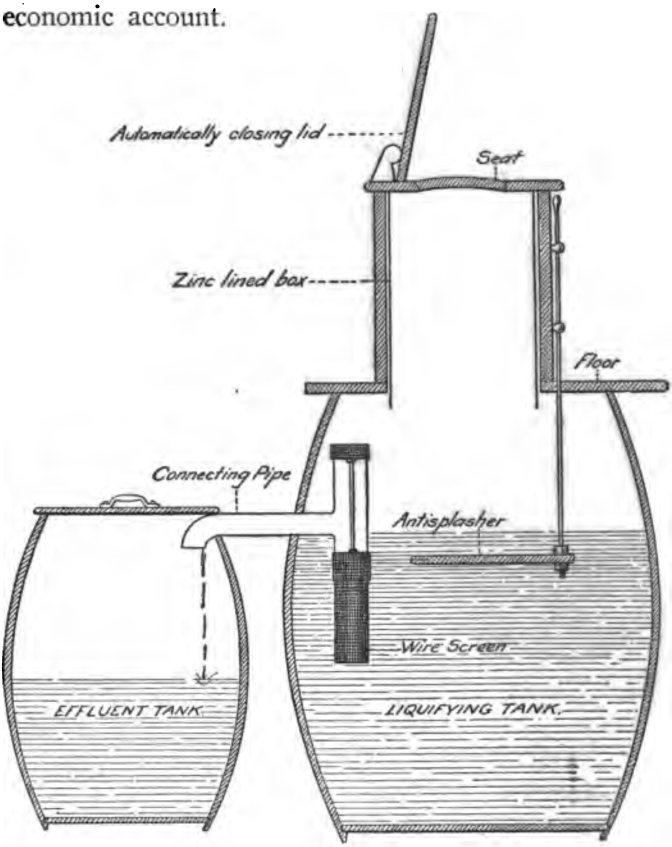

Fig. 40.—The Lumsden, Roberts and Stiles apparatus for the safe disposal of night-soil. (Redrawn from Lumsden, Roberts and Stiles.)

Construction.—The apparatus under consideration consists of the following parts:

1. A water-tight barrel, to be used as a liquefier.
2. A covered water-tight barrel, can, or other container to receive the effluent.
3. A connecting pipe about two and one-half inches in diameter, about twelve inches long, and provided with an open "T" at one end, both openings of the "T" being covered by wire screens.
4. A tight box, preferably zinc lined, which fits tightly on the top of the liquefying barrel; it is provided with an opening on top for the seat, which has an automatically closing lid.
5. An anti-splashing device consisting of a small board placed horizontally under the seat and one inch below the level of the transverse connecting pipe; it is held in place by a rod, which passes through eyes or rings fastened to the box, and by which the board is raised and lowered. The liquefying tank is filled with water up to the point where it begins to trickle into the effluent tank.

As an insect repellent a thin film of some form of petroleum may be poured on the surface of the liquid in each barrel.

Practical working of the apparatus.—When the privy is to be used, the rod is pulled up so that the anti-splashing board rises to within about one inch below the surface of the water. The fecal matter falls into the water, but this board prevents splashing, and thus meets one of the greatest objections thus far raised to the wet system. After defecation the person sinks the anti-splashing board by depressing the rod, and the

fecal matter then floats free into the water. We are now working on an improvement whereby the rod will connect with the automatically closing lid, and the anti-splashing board will rise and sink as the lid is opened and closed.

Although some of the fecal matter floats, it is protected both from fly breeding and fly feeding in the following ways: First, by the automatically closing lid; second, by the water; third, by the film of oil; and, fourth, for additional safety, the apparatus should be located in a screened place. The film of oil also prevents the breeding of mosquitoes in the barrel. Accordingly, so far as the privy as a breeding or feeding place for flies and mosquitoes is concerned, the model in question completely solves the problem.

The fecal material becomes fermented in the water and gradually liquefies; the addition of excreta naturally raises the level of the liquid, and the excess flows into the effluent tank, where it is protected from insects by the cover and by the film of oil. This effluent may be allowed to collect in the tank until it reaches the level of the connecting pipe, when it may be safely disposed of in various ways to be discussed later.

From July 12th to October 26th there have been 246 defecations (with urination) into the model in question, making about two and one-third defecations a day. The effluent has amounted to about twelve gallons of manageable fluid. It has not been found necessary to add water to the liquefying barrel since the apparatus was put into operation.

Although the period in question included the hottest part of summer, the odor, when compared with that of the average privy, has been negligible.

It is thus seen that this device appears to meet the following requirements:

1. It solves the fly and mosquito problems, so far as the privy is concerned.
2. It liquefies fecal matter and reduces its volume so that it may be safely disposed of more easily and cheaply than night-soil.
4. It reduces odor.
4. It reduces the labor of cleaning the privy and makes this work less disagreeable.
5. It is of simple and inexpensive construction.

The effect of the fermentative changes in the apparatus upon the viability of typhoid bacilli and hookworm eggs has not been determined, but other experiments tend to show that under such conditions the vast majority of typhoid bacilli and of hookworm eggs introduced would die within six weeks' to two months' time. While the time of storage can be prolonged according to the capacity of vessels provided for the purpose, we believe at present that it is safer and more practical not to depend upon storage alone to destroy infectious organisms in the effluent, but to consider the effluent infectious and to dispose of it accordingly.

Disposal of effluent.—(1) Heat: If a suitable (metallic) vessel is provided to receive the effluent, a fire may be built under the vessel and the effluent heated to boiling. Or if a wooden or concrete effluent tank is used,

the effluent may be transferred to some other vessel for boiling.

After boiling, the fluid may be safely used for fertilizer under any conditions.

Heat disinfection is the only measure which can today be recommended unreservedly.

(2) Burial: Burial will unquestionably decrease the dangers of spreading infection, but in the present state of our knowledge this method of disposal cannot be relied upon as safe. If burial of the effluent is practised, the fluid should be disposed of not less than 300 feet from and downhill from any neighboring water supply and not less than two feet underground, and then only provided the soil itself is a good filter. Burial in a limestone region may contaminate water supplies miles away.

(3) Chemical disinfection: Chemical disinfectants, such as chlorinated lime and certain coal-tar derivatives, have the great advantage of cheapness and can be relied upon to destroy pathogenic bacteria. Our knowledge regarding the action of chemical disinfectants upon the eggs and spores of the various animal parasites is at present very rudimentary, but so far as results are known, their practicable use does not seem to be so efficient in the destruction of the zooparasitic as of the bacterial infectious organisms. Therefore, pending further investigations, the use of chemically treated excrement as fertilizer should not be regarded as unqualifiedly safe.

(4) Chemical disinfection with subsequent burial:

Inasmuch as chemical disinfection can be relied upon to destroy pathogenic bacteria, and inasmuch as burial greatly reduces the danger from animal parasites, a suitable combination of the two methods (chemical disinfection and burial) can be used with reasonable safety.

(5) Sewers: In partly sewered towns, the effluent from these privies may be emptied into the sewers. If conditions are such that the addition of this material to the sewage is dangerous, then the entire sewerage system needs correction.

Paper.—Only toilet paper so far has been used, and the septic action seems to digest it. Other experiments indicate that newspaper would be disposed of by septic action in the tank, but perhaps some increase in the size of the tank would be required.

Cleaning.—Although no water has been added since the model was put into operation, the contents of the liquefying tank have remained fluid, and it is probable that in a tank having the capacity of an oil barrel, the amount of sludge from the dejecta of a family of five people would not be sufficient to require the cleaning of the liquefying tank oftener than once in six months to a year.